Enhancing the Lean Enterprise Through Supply Chain Design: Establishing Remarketing and Reverse Logistics at a High Tech Firm

by

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Submitted to the Sloan School of Management
and to the Department of Civil and Environmental Engineering
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SM Business Administration
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Abstract

During a difficult period of economic performance across the high technology industry, remarketing supported by reverse logistics has become a low cost way for firms to create additional revenues. Remarketing, the re-selling of used or refurbished equipment; and reverse logistics, the reverse flow of products from customers back to equipment manufacturers, together create a unique secondary market for high tech equipment. Due to the economic downturn, technology companies, including small companies and startups, have capped capital investments, thus reducing purchases of new equipment from instrument makers like Agilent Technologies. Remarketing thus allows Agilent to reach these customers who need equipment but are not able to buy new.

Remarketing supported by reverse logistics also presents several other positive benefits, including more focused disposition of products. By maintaining an effective reverse logistics system, remarketing managers get the final say on the disposition channel through which equipment exits the market. This allows managers to assess the value of equipments and parts, and to direct this equipment to the channel of greatest value. For example, certain circuit boards create significantly higher value being refurbished and reused as service parts than being sold through auctions. Likewise, other equipment containing hazardous chemicals can be disposed of and recycled in an appropriate channel.

Supporting a remarketing program requires that operations and supply chain managers understand how products flow through the entire value chain from product introduction to end-of-life. Managers thus have responsibility for designing reverse logistics and warehousing systems that effectively support growing remarketing programs. This research serves as a guide for operations and supply chain managers by providing analysis, methodologies, and design principles for establishing remarketing programs and reverse supply chains that create value for customers and enterprises.

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My father taught me an ethic to leave things better than I found them.

My mother taught me compassion to be a friend to those in need.

Every day I prove my mettle, whether or not I really learned.

My parents have taught me a great deal, for which I am grateful. I am also grateful for their encouragement while I have faced personal challenges and trials at MIT, and for their excitement and enthusiasm as I have experienced personal triumphs. A pep talk here, an insight there, a question, many prayers, faith, hope, and timely advice. I love you and appreciate you and hope that we may experience many more joys in life together.

I have had other teachers as well, who have stepped with me through the intense flames of growth found only at the very edge of my personal boundaries. Some have been formal teachers, others coaches, others partners, and others spectators. I am grateful to the professors who committed the best of their life's work to my education, namely: Thomas Roemer, Shoji Shiba, Charlie Fine, Debbie Nightingale, Peter Senge, Rick Locke, and Kevin Rock.

To the coaches, particularly Ted, Abbott, Bill, and Mike, thank you. Hopefully, I will understand and perform to the world-class level you expect of me. To the partners, especially Lou, and Chris, Esteban, Dave, and Roland, thank you for your support of me. If there is something great I accomplished at MIT, it was not my victory alone. And of my great memories at MIT, they are times shared with you. As we continue to work on the greatest opportunities in the world, I hope you will count on me as a partner and friend, that I may in some way repay the favor. Last, to the spectators, thank you for your support as well. My hope is that in the future we may join together on the playing field. I will try better to meet you half-way in extending an inclusive invitation.

I am indebted to many others who have helped me to arrive at this place in life. These individuals influenced me at the crossroads of my past, and the effect of their influence is continually revealed to me as I see the linkage of past choices with present and future opportunities. In this spirit, I acknowledge the important guidance given to me by Jan Scharman, Karen Duffin, Ron Atkinson, Dan Rohrbacher, Eileen Laca, Larry and Pam Haddock, Joanne Schatz, Sandy Braun, Sheri Webster, and Robert Yamashita. Their influence continues to be felt for good.

The value of an education can be determined in the way it changes our lives and our behaviors. While in this educational experience, of which I owe so much to the MIT Leaders For Manufacturing program, I have been the recipient of many intense lessons about business and life. Most importantly, I have been encouraged to push out beyond my limits and explore my personal boundaries in all aspects of intellect and life.

May I prove to those herein acknowledged the value of the education they have provided me. And may I demonstrate usefulness in this world a degree beyond what I have been so generously given of God and man.

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1.0 INTRODUCTION

1.1 Where can companies find cost advantages in today's competitive environment?

In the post-"tech boom" business world, many high tech companies are focusing on operational excellence as a means of reducing costs, eliminating waste, and maximizing shareholder value. Operations and supply chain managers are finding it increasingly difficult to capture big gains by turning over the same old rocks of inventory and logistics optimizations. The order fulfillment cycle—the means whereby products flow from suppliers to factories to customers—is becoming better characterized, and for many companies the problems associated with this forward distribution system have already been optimized.

1.2 The new frontier of progressive operations may be found going in reverse

A frontier of operational opportunities exists, however, in nearly every manufacturing company in its reverse product flows. Products returning to a manufacturer flow through what is called a "reverse logistics" system, as opposed to a logistics system supporting manufacturing and forward distribution. These products may return to the manufacturers for a number of reasons, including when: 1) the product is defective and the customer returns the product to its manufacturer; 2) the product does not meet customer expectations and the customer brings back the item to a retailer; 3) the existence of regulations require the manufacturer to assume disposal responsibilities, a prevalent case emerging in Europe today; 4) the manufacturer seeks to recover products for material re-use or recycling, as with transmission and alternator manufacturers; 5) the manufacturer seeks to recover products to control availability in the marketplace as is the case with certain high-end computing products; and 6) the product is being returned by customers at the end of a lease or demo arrangement.

1.3 Design of reverse product flows ignored in light of forward supply chains

Because operations managers are generally focused on optimizing the forward supply chain, the reverse supply chain is frequently ignored. Managers assemble reverse systems and processes in an ad-hoc manner and treat problems with the reverse supply chain as one-time chaotic fires to be put out. In this way, reverse logistics is viewed as an additional operational cost. As a result, the long-term opportunities to design and optimize reverse logistics systems are passed over.

1.4 Designing reverse logistics systems creates additional value

However, there are a few notable cases, such as HP's recovery of toner cartridges and an auto parts manufacturers' recovery of equipment cores, where reverse logistics systems are actively designed to create value. These designed systems contribute to firm-level strategies to satisfy customers, reduce materials costs, and create additional revenues.

Thus, we see company managers can create unique value in two ways: first, by analyzing and optimizing reverse logistics systems using forward distribution methods to reduce costs; and second, by designing reverse logistics systems to support strategic initiatives that produce competitive advantage and additional revenues.

1.5 Unique value created when reverse logistics is paired up with remarketing

We believe the latter—creating additional revenues—is a more valuable object of study for operations managers and academic investigators alike. Therefore, this thesis is focused on the unique combination that occurs when a reverse logistics system is designed to support a revenue-generating program, namely product remarketing. The field of reverse logistics, and especially the use of reverse logistics as a competitive differentiator, is not well-developed in academic literature, and even less developed in many supply chain and warehouse operations across industry. This thesis is based on both field research experience examining the business and operations of a remarketing program at Agilent Technologies, and an extensive literature review of best reverse logistics practices.

1.6 Thesis aimed at providing insights to operations managers and investigators

After understanding the concepts of reverse logistics and remarketing, we will study the key components required to support them. We will recommend practices and models for effectively managing reverse logistics facilities. We will then discuss the value of revenue-generating programs with remarketing as our case study, after which we will provide research findings in remarketing best practices. Throughout this work, we will highlight principles of supply chain design intended to assist supply chain and operations managers to actively craft reverse logistics and remarketing strategies and implementations.

1.7 Understanding reverse logistics and remarketing in a "lean" context

Last, we will place reverse logistics and remarketing in the context of a lean manufacturing enterprise and understand the implications of reverse logistics and remarketing on such enterprises. The lean movement, initiated and implemented in the Toyota Production System, has as one of its key components the elimination of unnecessary finished goods and work-in-process inventory. Many manufacturers in industry today have adopted lean inventory management as it pertains to supporting production lines; however, we know of no one that has considered reverse logistics in the context of lean. We will both seek to understand the impacts that reverse logistics and remarketing have on a lean manufacturer's broader set of stakeholders, or enterprise, and to apply lean and enterprise thinking to reverse supply chain design.

1.8 Knowing what to do when you look under these stones

The goal of this thesis is to provide supply chain and operations managers in industry with meaningful insights and to add new thinking to seminal works in the field of logistics. The story is unique—industry firms designing reverse logistics to support remarketing, thus creating competitive advantage and more broadly enhancing the lean manufacturing enterprise. We believe looking under the figurative stones of reverse logistics and remarketing will provide companies great benefits. This thesis provides managers direction for knowing what do to with what they find.

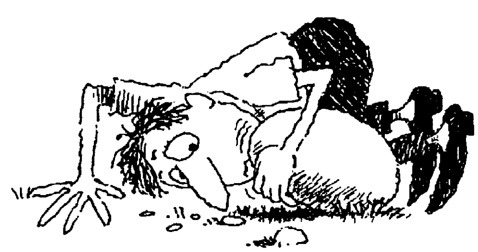

Figure 1: Managers looking under stones for operational gains must know what to do with what they find

1.9 Structure of the research

This research is organized to help the reader first understand the business and operational concepts of reverse logistics and remarketing, then to explore the unique value created by the establishment of such programs. Once the value proposition is established, a reader interested in establishing such programs learns operational principles for designing reverse logistics facilities and processes to effectively support remarketing. Having an understanding of the physical reverse logistics system and its processes, the reader learns of strategic issues and operational practices essential in creating a remarketing program. This discussion considers the pitfalls of revenue cannibalization and the value of a closed-loop supply chain. Last, the reader learns how remarketing and reverse logistics impact a company's broader set of stakeholders, or enterprise, and how "lean thinking" can lead to effective supply chain design. Throughout the thesis, examples from industry provide readers with insights into creating unique value through the establishment of remarketing programs supported by effective reverse logistics systems.

2.0 UNDERSTANDING THE BASICS OF REVERSE LOGISTICS

2.1 Seeing supply chain and logistics beyond the order fulfillment cycle

Today's supply chain managers operate in a context of global sourcing and global competition, where they are expected to engage suppliers across continents and facilitate the integration of parts and assemblies in plant networks. In short, supply chain managers are called upon to span the value chain, or enterprise, to maximize value to the customer and minimize cost to the firm. In most high tech firms, considerable investments have been made in the fulfillment supply chain—ranging from demand forecasting improvements to improved supplier selection criteria to implementation of lean manufacturing principles. Many firms have made the necessary investments in systems supporting lean principles, including just-in-time inventory systems, vendor-managed inventory, supplier coordination, supplier co-location, and massive information systems and warehouse technology solutions. These investments have yielded highly reliable order fulfillment processes and practices.

2.2 Reverse logistics: a new frontier of supply chain opportunities and problems

The field of reverse logistics, on the other hand, continues to plague supply chain managers with difficult problems. We define reverse logistics, or this reverse flow of products from customers to manufacturers in the following way:

> The process of planning, implementing, and controlling the . . . flow of raw materials, in-process inventory, finished goods and related information from the point of consumption to the point of origin for the purpose of recapturing value or proper disposal.[1]

Some examples of reverse logistics include customer product returns, manufacturer recycling programs and end-of-life product recovery and disposal by manufacturers. Problems

[1] Rogers, Tibben-Lembke, "Going Backwards: Reverse Logistics Trends and Practices," Reverse Logistics Executive Council, 1998, pg. 2.

associated with reverse logistics span the entire operating strategy, including the physical structure, systems structure, personnel policy and technology adoption and policy.[2]

Some of these problems include: difficulty in forecasting product returns due to random arrivals of products at storage and processing facilities; excessive logistics costs in reverse logistics channels due to a lack of logistics coordination and optimization (like the consolidated and optimized approaches found in the forward production logistics system), chaotic receiving processes at warehousing facilities designed to support forward production processes, and confusion for employees and managers caused by non-standard decision criteria and multiple channels for disposition.

2.3 Observing the differences between forward and reverse logistics

We spent several months observing the problems stated above at several different facilities of Agilent Technologies, a high tech firm specializing in high performance test and measurement equipment.[3] Anecdotes from operations managers at other firms also confirmed that these observations are a common occurrence throughout the industry. We noticed a marked difference between facilities supporting the forward order fulfillment cycle and those receiving product returns via reverse logistics. The problems above manifest themselves in several ways. First, the receiving and shipping docks of the forward distribution facilities were orderly and streamlined, whereas the receiving docks of reverse logistics facilities were cluttered with boxes and equipment, many of which were being held in "problems" areas.

Second, at the forward distribution facilities the warehouse management system was equipped with very sophisticated computers and tracking systems, whereas the receiving docks of the reverse logistics warehouses relied on multiple customized and unsophisticated MS Access databases. In the case of a very large computer manufacturer, the returns

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[2] Shapiro, Roy, "Key Components of an Operating Strategy," HBS Operations Strategy Course Notes, September 11, 2002.

[3] For a complete description of the internship, research and results, please see Appendix E.

warehouse operates without any bar-code scanners or computers at all![4] Last, because forward distribution facilities use and replenish inventory based on a schedule, we observed they had very orderly inventory storage bins and racks. Because of multiple disposition channels and non-standard disposition decisions and schedules, the reverse logistics facilities had bins with doubled up inventory waiting on a decision to be shipped or dispositioned.

2.4 Root causes of problems include lack of ownership and coordination

Digging at the root cause of these problems, we identify several issues that contribute to the difficulties described above. The first issue is that unlike forward logistics, there is no clear management responsibility or performance measures for reverse logistics. Reverse product flows represent a type of inbound supply chain that neither supports production plants nor serves the inventory replenishment cycle. In general, there is no clear single organization that owns reverse logistics. Reverse product flows can show up at a service parts warehouse or be returned directly to a factory. To complicate matters, because most reverse logistics operations are cost centers, the management response to reverse logistics performance is much different from profit and loss businesses.[5] These flows only seem to add cost and hassle, and are thus delegated to be dealt with at the lowest levels of the supply chain organization.

Compare this with the forward production cycle, where cross-functional teams work collaboratively to develop processes and practices that ensure products will be designed, manufactured, and distributed to effectively and efficiently provide customer value and capture market share. These teams are measured on their performance in every link of the product development and distribution chain. With reverse logistics, no such coordination, management ownership, or measurement exists.

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[4] Bowers, Sargeant, Musso, Bergmann, LFM Tiger Team Final Presentation, "ASL Reverse Logistics Design—ECO Purge Cost Model," February 7, 2003.
[5] The McKinsey Quarterly, "The Secret Life of Factory Service Centers," Publication 2002 Number 3, http://www.mckinseyquarterly.com/article_page.asp?ar=1208&L2=1&L3=24&srid=69.

2.5 Reverse logistics product flows result in a disparate logistics network

Product returns are either pulled proactively by company customer service and marketing programs or pushed by customers back onto manufacturers. Customer support personnel assign return merchandise authorizations (RMA) or other field authorizations that provide appropriate financial transactions to logistics providers and internal organizations along the reverse supply chain. Except where expressly tied to company policy (like in the case of an RMA stipulating a certain carrier), transportation efforts are handled by disparate local and national carriers. Depending on where products are sent, there may be several processing points handled by disparate third-party logistics providers.

2.6 Reverse product flows that are not designed result in ad-hoc processes

At the highest levels, reverse logistics processes are not designed at all—these processes develop over time as a means of dealing with what appears to be random customer or product problems. Operations managers focused on forward fulfillment cycles create patchworks of ad-hoc processes to deal with these problematic product returns and reverse product flows. Generally, operations managers do not take the time or expend the resources to re-engineer these ad-hoc processes because in most cases, reverse logistics is an unintentional aspect of the business. Thus, process engineers are not assigned to engineer new processes to improve reverse product flows. Also, because managers allocate little funds to this aspect of the business, there is little ability for process engineers to significantly alter current information systems or personnel supporting the reverse logistics processes.

2.7 Reverse logistics processes require different support systems

Recognizing that reverse product flows are different in certain ways than forward flows, we see that different information and support systems are also required. For example, a typical reverse logistics process is described below in the form of a service parts repair at a customer site. Note that this is a designed process, and is referred to here to illustrate different system requirements for the reverse channel.

2.7.1 An example of a reverse logistics process and associated support systems

A technician conducting a routine repair at a customer site might utilize the company's reverse logistics system in the following way. Let us assume he already has the spare part he will use at the customer site. In this case, he replaces a high-cost component tagged for recovery by the company. After the repair, the field technician seeks appropriate authorization through the company's information system to return the part. If the part is not returned, the repair service organization will be assessed a fee. Upon receipt of the authorization, he packages up the product and ships it to a specified warehouse operated by a third-party logistics provider (3PL) via a specified carrier. Upon receipt at the warehouse, workers verify the product being received, scanning bar codes and checking product options, etc. Information is requested and submitted into the 3PL's inventory system. Once product confirmation occurs, financial transactions are performed via other financial information systems, providing payment and receipt invoices to appropriate internal and external customers. Finally, a field support information system used by the field technicians and customer support group is utilized to close out (also known as "call closure") the temporary service request created for the customer.

From this example, we see that the service organization is operating on different systems entirely from the forward order fulfillment system. The systems supporting the service organization have been customized over time by both company and non-company personnel to support a specific set of transactions much different than the transactions of the forward order fulfillment process. However, we see that even in this case, where the processes and systems are actually designed, there are many differences in the support systems used to support reverse logistics. In a case where the processes have not been designed, but have developed ad-hoc, the differences in support systems and processes is even more pronounced.

2.8 Lack of management support and complex systems result in resource mismatches

Above we have outlined how reverse logistics systems develop ad-hoc as different problems arise and that there is generally no clear management accountability for system performance. These two forces result in resource mismatches, or the application of a system or solution not intended to be used on the type of problem being considered. In logistics these resource mismatches occur as low-cost patchwork systems are applied to legitimate logistics problems, thus perpetuating the development of additional disparate systems. We use an example to illustrate the point.

2.8.1 Example of how resource mismatches create even more systems

A very large computer manufacturer needed to track inventory purges from its field stocking locations. Purged inventory would flow through the company's reverse logistics network. In order for a purge to be approved and executed, many different parties were required to sign off on the purge order. Then the inventory would be tracked until received at the local warehousing facility. Because so many disparate parties were involved along the reverse logistics chain, and because no single manager or organization had control over the process, patchwork systems were set in place by warehouse managers and workers. Without managerial support or funding, the local workers began using an existing CRM (Customer Relationship Management) application to open and track purges as though they were customer complaints. Various engineers and managers in the process would provide signatures and approvals through this CRM system.[6] Use of this type of system created discrete administrative steps that caused the company to lose time and money. The system also created a confusing method for thinking about the reverse logistics product flow. While we applaud the creativity of these local workers in using the resources available to them, the creation of a custom system mismatched to a problem serves to add complexity to the reverse logistics system. Additional complexity occurs when such systems are established on different database platforms (MS Access, SQL, Oracle, CRM systems, Legacy systems, COBOL, FORTRAN, etc.). In our observation of industry, this type of custom system proliferation and resource mismatch at lower levels of the reverse logistics supply chain is pervasive.

[6] Bowers, Sargeant, Musso, Bergmann, LFM Tiger Team Final Presentation, "ASL Reverse Logistics Design—ECO Purge Cost Model," February 7, 2003.

2.9 Seeing the differences and considering the opportunities

As we can see, the information, financial, and personnel systems in a reverse logistics supply chain are complex and different in many ways from the forward order fulfillment cycle. A different set of issues arise with reverse logistics due to managerial responsibility, transactional complexity, and ownership by several different company and non-company departments in the chain.

Complexity and differences aside, opportunities exist for managers to analyze, understand, and design reverse logistics systems to be more cost-effective, and in some cases to serve as a support structure for generating additional revenues. In designing reverse logistics systems, managers begin to transform random problems into characterized opportunities with well-defined responses. In the next section, we will discuss some of these opportunities for using a reliable reverse logistics system for generating additional value for the company.

3.0 The Value Proposition for Remarketing and Reverse Logistics

3.1 Spectrum of reasons why companies get involved in reverse logistics

If reverse product flows are so difficult and troublesome to manage, why do companies get involved with them? Ultimately, the answer to this question is to be found in managers' perspectives on reverse logistics. The chart below helps to paint a spectrum of possible perspectives managers have of reverse logistics.

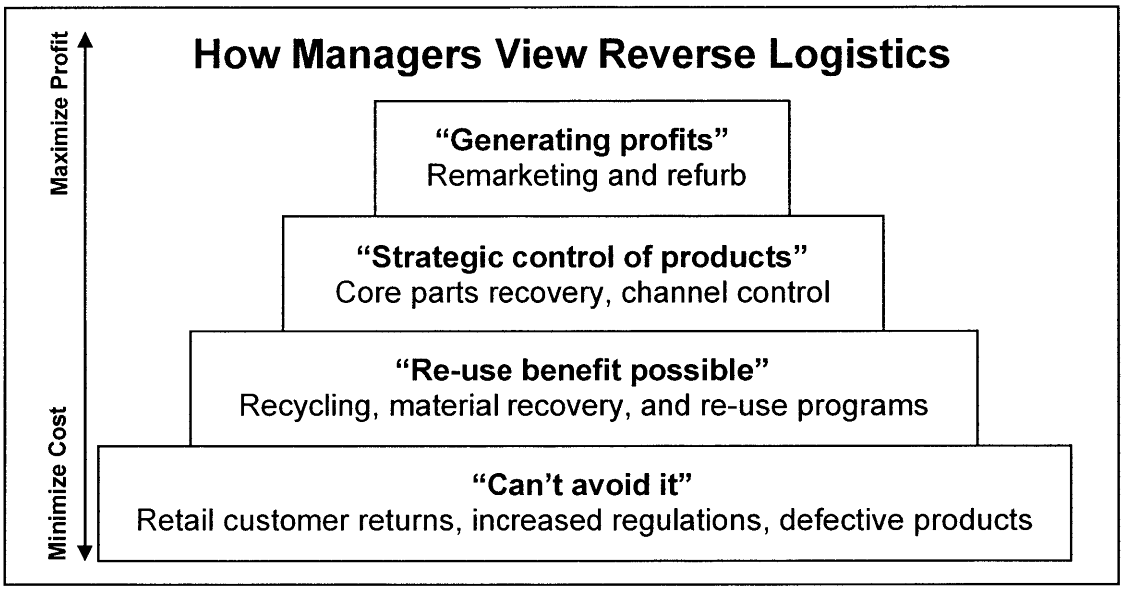


Figure 2: How managers view reverse logistics

3.1.1 Management perspective: "We can't avoid it"

At the very base of the hierarchy is the view that a company simply can't avoid reverse logistics because of obligations surrounding customer returns, regulated responsibilities, or warrantees on defective products. This view leads companies to focus on reducing reverse logistics costs rather than investing in an optimal system that can create more value for the company.

Regulations are forcing many companies to start reverse logistics programs to support end-of-life product recovery, especially in Holland and the European Union. Governments in these countries are beginning to require companies to take more responsibility for product end-of-life disposal, as opposed to landfills managing all of the waste. This requires active tracking and recovery activities for these supply chains. Once products are recovered, many companies find ways to recycle or use the products in other ways.

3.1.2 Management perspective: "There are reuse and recycling opportunities"

Stepping up the hierarchy, companies become more active in their efforts to recycle and reuse materials as a means of reducing costs. There are two ways in which costs can be reduced through recycling and reuse. First, companies can directly reuse the product or parts of the product itself. For instance, HP recovers laser-toner cartridges for direct reuse in manufacturing with minimal refurbishment. The same technique is used by Kodak in manufacturing its disposable cameras. Some high tech firms with high-value product components recover products for the purpose of tearing down the equipment to extract expensive components and parts, many times rotating these parts into manufacturing lines or service parts inventories utilized by field technicians during product repairs.

A second method of using recycling is the more traditional method, where input materials are recovered and re-processed at a lower cost. For instance, spring water companies reuse and recycle plastic water bottles to reduce input and product costs. This approach is more applicable in traditional raw materials businesses.

3.1.3 Management perspective: "This is a means of ensuring strategic control"

Some companies view reverse logistics as a means of product recovery for strategic control. Companies utilize product recovery through reverse logistics channels in order to maintain control over product disposition, pricing, and technology. Companies wish to dictate how much of their products are fielded through which channels at what prices. They also wish to protect valuable intellectual property. Product recovery allows companies greater control over these factors and provides the means by which companies can capture value for themselves rather than letting other value chain members capture additional value for their products.

One example of strategic control can be found in the auto parts and repair industry. Ford Motor Company desires to control transmissions for refurbishment and reselling. Because many Ford dealerships are privately owned and operated, service parts personnel are not concerned with which remanufacturer buys used transmission cores. Dealerships selling to third-party remanufacturers loosen Ford's strategic control on this very valuable product. To address the issue, Ford created a reverse logistics system in which a single nation-wide logistics provider ensures that transmission cores are recovered from dealership service centers and returned to official Ford recovery facilities. In this way, Ford maintains strategic control over high value parts used for generating revenues.[7]

3.1.4 Management perspective: "Reverse logistics can help us increase profits"

In the top tier of the hierarchy, managers view reverse logistics as a means of generating additional revenues and profits for a company. Managers with this perspective see maximizing profits as the objective of their business, in addition to managing costs associated with the operations. Many high tech companies including GE, HP, Agilent Technologies, Dell, 3M, Xerox, and IBM[8] are getting involved in this top tier of reverse logistics as a means of generating additional revenues and customer value.

In these firms, managers design reverse logistics systems to recover products as a reverse supply source for refurbishment and remarketing. Products that are successfully remarketed have high profit margins. The cost of goods sold for these products is very low in comparison to products going through the complete production and distribution process. Companies remarketing products focus on reaching different customer markets to avoid cannibalizing their top product markets. Companies use several means to recover products, including providing customers with trade-in value for new products. After recovery, products can be refurbished and resold or utilized in reuse and recycling opportunities.

[7] Rogers, Tibben-Lembke, "Going Backwards: Reverse Logistics Trends and Practices," Reverse Logistics Executive Council, 1998, p. 179-180.

[8] Information regarding reverse product flows at these companies are taken from the following sources:

- Bowers, observations from internship at Agilent Technologies
- Rogers, Tibben-Lembke, "Going Backwards: Reverse Logistics Trends and Practices," Reverse Logistics Executive Council, 1998.
- Brito, Flapper, Dekker, "Reverse Logistics: A review of case studies," Econometric Institute Report, May 2002.

3.2 Each tier in the hierarchy represents another level of reverse logistics sophistication

Stepping up the tiers of the hierarchy, we see a progression of how managers think about the business problems they are facing and a structure for how reverse logistics can provide greater profitability. The hierarchy is layered because each of the tiers is foundational for the next layer. Operationally, a higher-level view results from a higher-level reverse logistics system.

3.3 How do operations managers establish the proper level of reverse logistics?

How can operations managers decide how far up the hierarchy they should go in developing their reverse logistics systems? The answer lies in both the nature of the product and the strategic fit of such a program. The nature of the product may dictate how far up the hierarchy a company can actually go with a reverse logistics system. Let us consider a few examples.

3.3.1 Example one: Alcoa and recycling

First, Alcoa, one of the world's leading raw aluminum stock providers may seek to establish a reverse logistics system to support product recycling in order to lower its material manufacturing costs. However, because the company deals in a commodity good, there is little value for Alcoa to invest in a system that provides support at a higher level in the hierarchy, like strategic control or remarketing. If Alcoa were a monopolist, there may be a strategic fit in recovering all of the world's aluminum for strategic control, but in the current competitive environment and with competitive recyclers around the world, such a system would most likely be a waste of resources.

3.3.2 Example two: Delco and the full spectrum of reverse logistics

A second example is Delco, an automotive parts supplier. Depending on the product, Delco may choose to develop reverse logistics systems anywhere along the hierarchy. Some plastic and gold components would be recycled, alternator cores would be recovered for reburbishment and remarketing, and Fiberglas parts would not be sought after at all. Strategic fit for this company and these products would make sound business sense.

3.3.3 Example three: Home Essentials and customer service

A third example is a retail supplier, Home Essentials, who sells floor lamps. The product is not extremely valuable or complex, and customers may choose to return it to retail stores at any time. The company strategy for this product is to provide stellar customer service in order to attract more customers and please the retailer selling the product. Thus, managers should develop Home Essential's reverse logistics system at the most basic level of the hierarchy, but make the systems (i.e. RMA processes) easy for retailers to use. In this way, reverse logistics creates a competitive advantage wherein retailers prefer Home Essentials' products for their handling of returns.

3.4 Managers choose reverse logistics level based on product and company strategy

From these three examples, we see several criteria whereby managers may develop reverse logistics systems, namely: product value, product complexity, the existence of a secondary market, customer service requirements, and strategic fit with the stated hierarchy. Decisions to build a more or less advanced reverse logistics systems than is appropriate will result in either wasted resources or lost market opportunities.

3.5 Designing effective systems requires understanding the product enterprise

In order to design effective reverse supply chains and remarketing programs, supply chain managers must be able to couple firm strategy to appropriate operational measures like those described above. Managers are responsible for understanding and optimizing costs and opportunities in the product value chain. At the same time, they are responsible for managing operational activities along the entire product life cycle (as seen in the exhibit below).[9]

[9] Bowers, "Lean Enterprise Model," presented to Integrating the Lean Enterprise course under direction of Debbie Nightingale, Fall 2002.

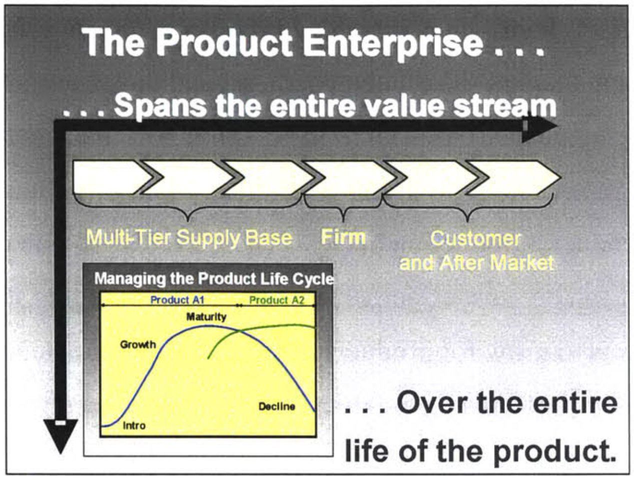


Figure 3: Managers must understand the product enterprise

In order for an operations manager to design a reverse logistics system and a remarketing program, she must consider the whole value chain, from the supply base to the customer and the after market. Considering the value chain provides insight into the stakeholders involved in establishing the process and the systems that will need to be created in order for the program to be successful.

3.5.1 The difficulty of design is always at the interfaces

In designing the supply chain, operations managers should be asking questions about the interfaces of the value chain: How are customers using our remarketed products? Through what channels will our products reach the customer? Through what means will we be able to recover the product? Where in the supply base are there opportunities to augment factory production through parts reuse? Who will manage the relationship with customers? Who will handle inventory in the system? What interfaces will we keep in house and what will we outsource?

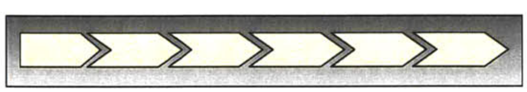


Figure 4: Inter-organizational interfaces occur long the product value chain

These critical questions help managers design along the dimension of the product value chain.

3.5.2 The product life cycle provides insights into reverse logistics design

Further, supply chain managers should consider a second dimension in planning for reverse logistics and remarketing needs. As seen in the graph below, managers should plan their reverse logistics and remarketing programs over time. Managers should consider the product life cycle and new product introduction cycles. These cycles provide insights into when a remarketing program can be most effective. For instance, managers should expect the supply of recoverable products to grow for products entering the decline stage, especially if a newer, less expensive or higher performance product has been introduced into the marketplace. Also, by looking at warranty periods, leasing agreements, field failure rates, and trade-in programs and terms, managers can gain insights into product recovery quantities and prepare the reverse logistics system for these reverse product flows. In so doing, managers can take away much of the chaos of "random" product arrivals and problems, and can create planning methodologies for optimizing reverse logistics performance.

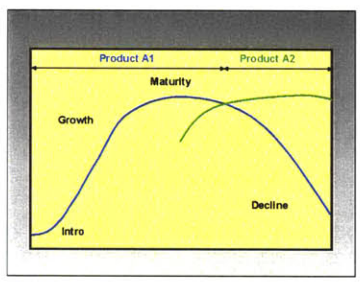


Figure 5*:* Product availability depends on stage in the product life cycle

3.6 Looking more deeply at the elements of the reverse logistics system

Provided we understand the concepts and value of reverse logistics presented above, and the way in which reverse logistics supports various returns and remarketing programs, we are prepared to understand more deeply reverse logistics strategies and implementation tactics. We begin our discussion by focusing on the physical facilities of the reverse logistics system, as this is the fundamental resource required to provide such a system.

4.0 THE IMPORTANCE OF FACILITIES MANAGEMENT IN SUPPLY CHAIN DESIGN

4.1 Developing analyses and practices for optimizing warehouse facilities

Physical facilities and inventory management are crucial to effective reverse logistics and remarketing programs. Thus, facilities management and specifically warehouse management is a topic of great concern. Managers need analyses and practices for optimizing warehousing facilities preparatory to supporting effective reverse logistics and remarketing programs. In this section, we discuss an operational model (see figure 6 below) that highlights the facilities issues managers implementing a reverse logistics system will face, including cost, activities, utilization, and space. Note that warehousing facilities may include facilities owned or operated by the company and/or a third-party logistics provider (3PL).

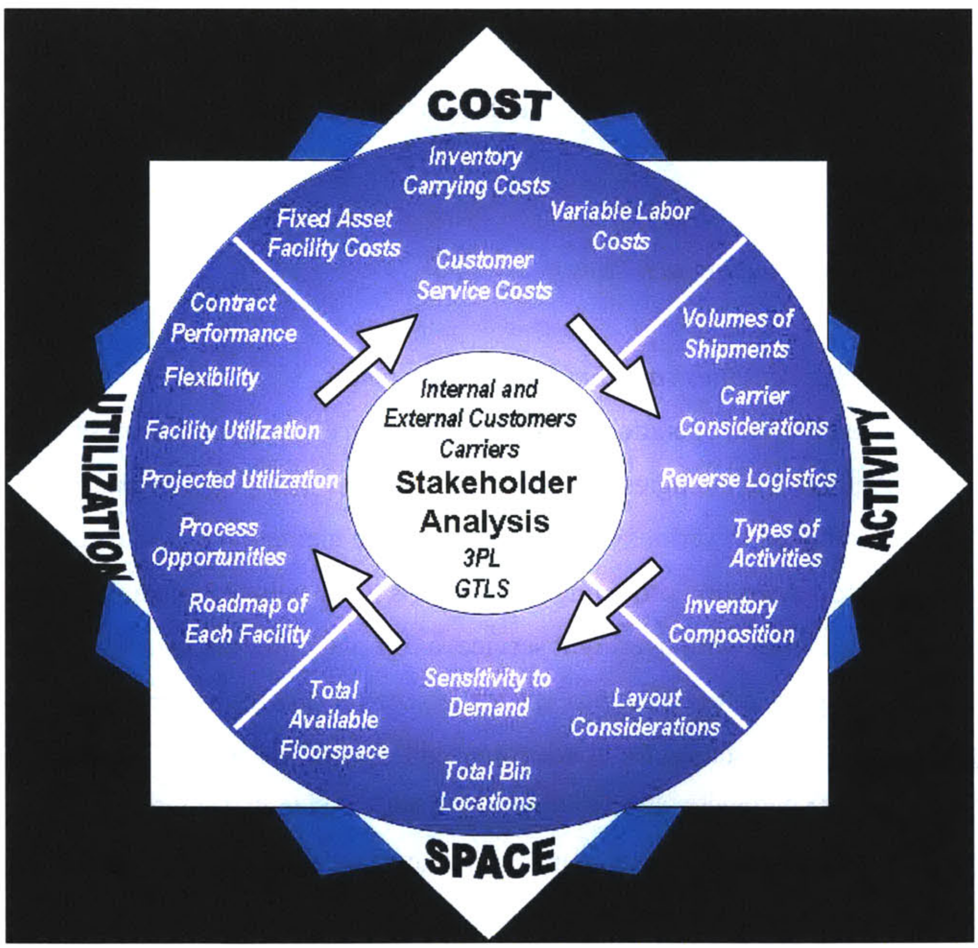


Figure 6*:* Operational model for facilities management in supporting reverse logistics

In the case of Agilent Technologies, this operational model was used to analyze warehousing facilities and policies to assess opportunities for operational improvements affecting the overall reverse logistics system. This analysis produced recommendations for warehouse consolidations and the subsequent implementation resulted in $1.4M of savings and operational improvements to Agilent's central reverse logistics organization.

4.2 Factors in the model must be considered over time

Each of the factors in the model is dynamic in nature. Thus, in creating lasting improvements, it is essential to capture how each factor will change over time and how these changes will affect warehousing facilities. To provide order to our study of facilities dynamics, we consider the main drivers presented in the model above. Upstream internal and external stakeholders in the enterprise dictate needs and requirements to facilities managers, who in turn generate activities to meet those needs and requirements. Because of this hierarchy, we will start our analysis by examining activities as the main consideration in this model.

4.2.1 Analyzing warehousing activities

Warehousing activities vary and change over time

Activities include all of the operational functions necessary to support business requirements. In the case of Agilent Technologies, warehousing activities include a merging process where products being produced in various parts of the world are merged into single customer shipments, a support operation providing service parts to all field technicians throughout North and South America with overnight service, a receiving process for product returns for a re-marketing program, a receiving process for returned IC boards as part of a IC board exchange program, and a station for conducting "call closure" or confirmation of field repairs conducted by field technicians. Further analysis of activities includes understanding carrier requirements (ie. cutoff times), product mix and associated handling requirements, and volumes of products being handled in each activity.

Operational activities provide increased customer value

The ideal set of activities maximizes customer value and further supports the goals of the enterprise. For example, merging or consolidating disparate products together provides the customer with a single delivery and installation by technicians, as opposed to customers wasting time and effort waiting for the product to arrive piecemeal. Such alignment of activities to customer value is a critical responsibility of product and operations managers.

New value propositions require operational flexibility

Operations managers change warehouse activities as they discover and implement value propositions that maximize customer value. For instance, product merging may provide value in today's environment, but as information and logistics systems evolve, future activities may include "merge-in-transit," where a 3PL or carrier handles product consolidation within a two to three day window. In such a case, product merging facilities become obsolete and open up space for alternative uses. Managers, seeing a shift in the logistics value proposition, must consider other activities to effectively utilize the facility. Given that activities will change over time to meet customer needs, managers must maintain flexibility inside their facilities order to change activities appropriately. Operations managers must also be aware of how the effects of changing activities ripple through the entire facility.

Three-year plan helps assess future activities and demands

At Agilent, the effects of changing activities over time was assessed through a planning process outlining key initiatives coming online over a three-year period. These activities, seen in the "Events, Initiatives, and Dynamics" portion of the strategic plan seen in Appendix A, show a shift in activities aimed to increase value to customers and to lower costs to Agilent. This shift in activities will affect each factor in the operational model, but most directly the changes will drive space requirements as seen in the graph in Appendix A.

4.2.2 Space Considerations

Assessing changes in activities provides insights into space needs

Different activities and requirements drive different space needs. In Appendix B, one can see an expanded list of activities taking place in Agilent's RL warehouse and the total square footage of warehouse space being occupied by each activity. The Philips column represents activities that were being discontinued as they were moved to Philips in MA after its acquisition of the Agilent medical business.

Managers should consider several space diagnostics

Because warehouse space is essential to managing the logistics and distribution activities of any manufacturer, special attention must be given to the dynamics affecting warehousing space. The Philips move as seen in Appendix B frees up over 30,000 square feet of warehouse shelf space. Of course, measuring shelf space is only one of several space diagnostics. Other considerations of warehousing space include: total available floorspace, total bin locations and bin types, layout considerations, and sensitivity of space to demand. We see that warehouse space is also impacted by issues of utilization, or issues of how the space is used. This interplay is discussed in the next section.

Facilities changes lag changes in activities

Generally, facilities changes occur more slowly than changes in activities or uses of those facilities. Thus, at any given time, there will exist gaps between current facility configurations and current activities or uses of those facilities. This is in part due to first, the high cost nature of facilities changes, and second, the lag time for issues related to activity-facility disconnects to be escalated to management. By examining facilities with a focus on how activities will change over time, managers can better match facilities to needs in the future. Managers, knowing that demands on facility space will change over time, can also design flexibility into facilities and systems to minimize changeover time and costs.

Altering warehouse layouts can increase flexibility

In the case of Agilent, analysis of changes in activities revealed opportunities for changes in warehouse layouts that would effectively increase floorspace and create buffer space for shocks in demand. Specifically, assessment of the elimination of government packaging activities and changes to piece part merging processes pointed to "monuments" creating waste in fulfilling new activities. These monuments, in the form of a caged space and a merging conveyor belt runway that blocked a major facility opening, stood as obstacles to flexible operations.

From this example, we see that analyzing warehouse layouts and considering alternative configurations can point to opportunities for improved flexibility in the warehouse space. In this case, eliminating the conveyor belt runway freed up approximately 8,000 square feet of warehouse space, now used to hold piece parts and to serve as a buffer area for orders affected by the implementation of a new ERP system.

4.2.3 Space policies

Space policies provide a check for inventory expansion

Setting in place certain space policies makes it is easier for managers and employees to spot opportunities for change. Good facility space policy, as suggested by Dr. Abbott Weiss, recognizes that just as gas expands to fill available space and work expands to fill available time, so does inventory expand to fill available space if left unchecked. This can be explained by managerial incentives. Operations managers are incentivized for fully utilizing fixed assets, and product managers are compensated for having high customer service levels. Thus we see managerial behavior driving inventory to balloon to fill available spaces.

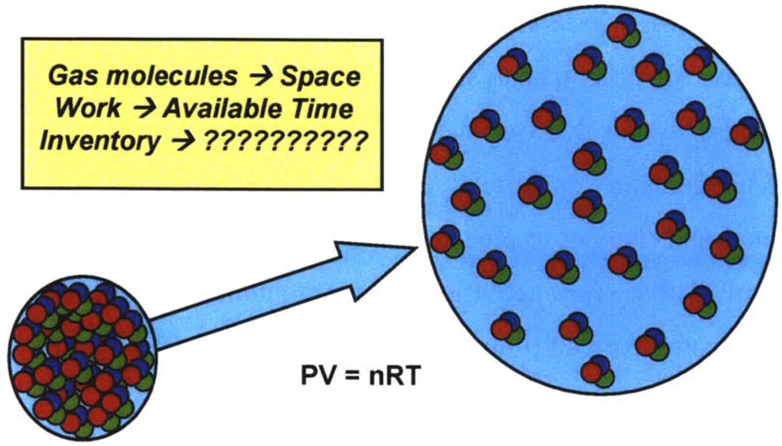
Space policy can be likened to gas laws of physics

A more direct analogy to this principle of inventory expansion can be found in the Ideal Gas Law, an equation that relates the volume, temperature, and pressure of a gas to the type of gas present.

The equation reads: [10]

PV = nRT,

where:



V = volume in liters

n=moles of gas

P=pressure in atm

T=temperature in kelvins

Figure 7: Gas law of inventory—inventory expands to fill available space

R is the *molar gas constant*, where R=0.082058 L*atm*mol-1*K-1, where L is liters, atm represents atmospheres, and K represents temperature in Kelvin.[11]

Understanding the speed at which inventory is moving

The first principle to take from this equation is the nature of gas molecules. Larger molecules move more slowly and have larger mass. We see in a high tech environment that large and expensive pieces of machinery move fairly slowly through the manufacturing and distribution channels. Spare parts and exchange boards, on the other hand, are highly re-useable modules that move quickly through the distribution channels. Recognizing the difference gives context for understanding the nature of material movement in a facility.

Equation analogous to warehouse space and inventory

Let us examine some of the other key components of the gas equations. V volume can be likened to warehouse or facility space, n moles to the amount of inventory on hand, T temperature to the priority given to inventory movement ("hotline" items will be moved through the system very quickly), P pressure to the management policies on order fulfillment,

[10] The Ideal Gas Law is contained in most physics and chemistry texts. One example includes: Zumdahl, Steven S., "Chemistry," Fourth Edition, Chapter Five, Houghton-Mifflin Company, 1997.

[11] R is the universal gas constant with terms stated: liter atmospheres per mole Kelvin. This specific definition taken from: http://dbhs.wvusd.k12.ca.us/GasLaw/Gas-Ideal.html.

and R molar gas constant to the average speed at which the fulfillment process normally takes place (pick, pack, ship times or the TAKT[12] time of the facility).

Pressure determined by velocity and temperature

Decomposing these variables can help managers determine policies. Gas molecules increase their velocity with increases in temperatures, thus increasing pressure on the container holding the gas. Velocity through the inbound (receiving and putaway) and outbound (pick, pack, and ship) processes determine the pressure on the facility. Operations managers may also consider these inbound and outbound processes as constraints or "bottlenecks" in the system. In the case of an Agilent spare parts facility, carrier cutoff times translated into field technician order cutoff times. Due to management's policy that every order received would be turned around before the day's end, orders per day determined the pressure on the outbound system. With 4,500 to 6,500 orders received per day (as seen in the following distribution), a certain velocity must be maintained through the outbound processing stations of the facility in order to meet cutoff times.

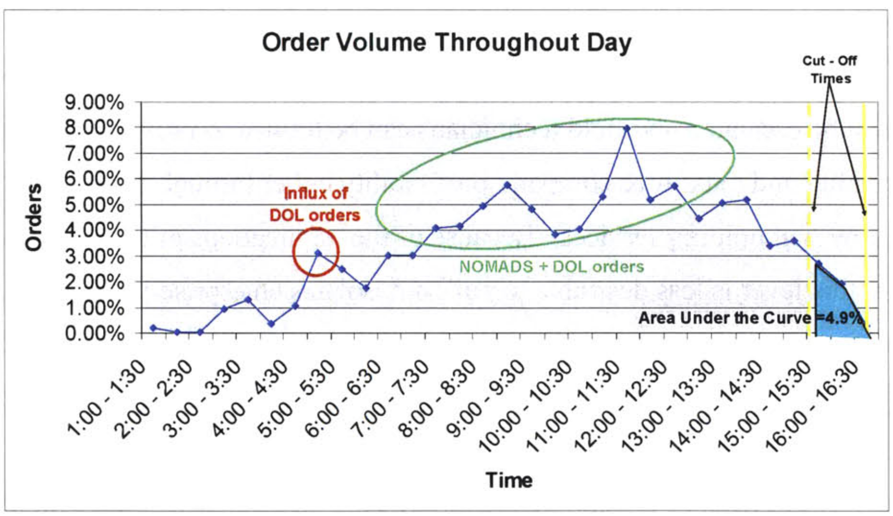


Figure 8: Outbound processing velocity must ensure that order volumes are delivered before carrier cutoff times

[12] TAKT is a term used in lean manufacturing, signifying the desired rate at which units should flow through a manufacturing facility. TAKT is based on the equation: TAKT = Time Available / Customer Demand = the number of units that need to be produced in a certain time period to meet customer demand.

Managing pressure and velocity by improving processes

Not to over-generalize science to facilities, but we can see that there are several levers available for managers to pull to maintain certain levels of pressure on the system. Some levers are more practical and/or effective than others in accomplishing goals of high customer service levels and low costs. The most effective lever is to manage inbound and outbound processes and capacities. Doing so manages the velocity of materials through these processes and serves to either increase or relieve pressure on the system. As discussed more thoroughly in the next section, improving processes increases capacity and eliminates the need for buffers.

Managing pressure by spreading out demand

The second lever is to reduce the "temperature" in the system by working with field technicians to lower the occurrence of "hotlines," or items that are deemed as emergency items needed by 8:00 am the next day anywhere across North America. In many instances, field technicians are providing a higher level of service than that contracted by the customer; thus, while providing goodwill to customers, the systematic use of "hotlines" is increasing pressure at the warehousing facility. Working across operations and sales organizations, problems can be escalated and field technicians can be trained to provide exceptional customer quality and maximize company profitability either through expanding existing contracts or by withholding services. Because of the implications of this lever on customer satisfaction, this lever is less desirable to pull, but isolates enterprise-wide opportunities to increase customer and company value.

Relieving pressure through volume expansion

The third lever is to expand volume to relieve pressure. This expansion occurs through either the addition of facility square footage or adding labor capacity to handle processing. This lever has two managerial analyses tied to it. First, the manager should ask if he/she is running from operational problems by giving more capacity for inventory, or if in fact the business needs more space in order to operate effectively. Second, the manager should estimate the cost impact versus the improvement in customer satisfaction associated with the expansion. This lever should only be exercised after managers have stepped through the two analyses described above, else the expansion will have a negative effect on the overall performance of the business.

Gas law analogy creates practical managerial levers

These three levers—managing process velocity to manage pressure, managing order patterns to regulate temperature, and managing facility expansion to manage inventory volume—are helpful points for managers to consider in crafting space policies. As various activities occur over time in the warehouse facility, space requirements must be considered accordingly.

Space management requires focusing on utilization

Because of the dynamic nature of activities occurring within the facility, space requirements need to be considered in aggregate and must reflect boom-and-bust sensitivity analysis. As managers gain confidence in space requirement estimates, they should next begin to look for opportunities to improve utilization of their fixed-asset facilities.

4.2.4 Utilization

Utilization key to achieving business goals

In the operational model above, utilization is described as including issues such as individual facility utilization, projected utilization based on activities within each facility, process opportunities, flexibility, and a roadmap of each facility and changes that may be occurring within each facility. To carry forward the gas law analogy introduced above, an equilibrium pressure will develop in any facility based on the activities taking place in a warehouse of a certain size. The issues of utilization described above are especially important to maintaining warehouse sizes and activities, which will ultimately translate into supply chain cost performance. As we consider the goals of the business (Return On Equity) and the goals of the supply chain (customer satisfaction with minimum cost), we can begin to assess opportunities for utilization improvement. For clarity's sake, we will define utilization as the percent usage of a given resource; in this case, warehouse utilization is the percent usage of available storage bins and spaces intended to serve as warehouse storage space.

Facility utilization serves as important performance metric

Facility utilization is an important diagnostic because it points to other opportunities related to facilities management. For instance, if the storage bins of a warehouse are at 120% utilization, there may not be enough bins in the warehouse; or the inventory may not be turning over quickly enough and thus material is collecting on the shelves; or possibly the system has evolved over time to accommodate more parts per bin than in the past.

Utilization points to opportunities for consolidation

In the case of Agilent, low utilization rates in three different facilities pointed to an opportunity for consolidation of facilities. Looking to Appendix C, we see that facility utilizations were 20%, 50%, and 90% for three different facilities. In light of our discussion above regarding space management policies, proposals were drafted that reconfigured the largest facility to accommodate the activities of the two other facilities.

Consolidation increases pressure and improves utilization

Consolidation provided both direct and indirect financial and operational benefits. By eliminating the two smaller facilities, the company was able to reduce lease payments by 30%. Indirectly, bringing all activities under one roof required managers to define and refine existing processes and configurations to ensure that activities could run effectively and efficiently. In analogy to our gas laws above, bringing more molecules of activity into the same facility (inventory and fulfillment processes) increased pressure and demanded better utilization and increased velocity. Thus, we see a manager's law (Graham's Law) as seen in Appendix A, demanding "Increased activities" and "improved efficiencies." Additionally, consolidation allowed facilities managers to more effectively coordinate employee schedules and to provide opportunities for cross-training in other activity areas, resulting in greater flexibility of the workforce.

4.2.5 Process-Driven Utilization Improvements

Improving utilization requires understanding processes

Consolidation places pressure on the performance of inbound and outbound activities of a warehousing facility. In order to improve processes, operations managers should implement "lean" principles of waste elimination. As was discovered in Agilent's facilities, most physical processes (receive, put away, pick, pack, ship, etc.) and process flows are tied to other transactional processes and flows, including financial flows and information flows. The table below presents the attributes of physical, financial, and information processes:

Process Type	***Characteristics and Attributes***	***Example***
Financial Transaction Processes	• Connects internal and external suppliers to company • Provides payment to value chain participants • Involves multiple and complex systems • Systems drive behaviors and processes • Creates redundant physical and information flows	- Invoicing - Payment upon receipt or upon shipment - In absence of ERP, multiple legacy systems - Product routing occurs in order of transactions - Multiple receiving entries for same product
Information Processes	• Managed through complex systems • IT systems dictate physical process flows	- ERP system - Wireless barcode readers change limits
Physical Processes	• Key contributor to cost in forms of handling, carrying, freight, shipping and receiving costs • Easiest part of process to analyze • Interplays with information and transactional processes	- Per unit costs of processing and shipping products - Physical flows allow for physical observation - Scanners, readers, physical facilities

Table 1: Processes affecting facilities management

Warehouse processes are driven by transaction processes

Improving warehouse practices involves understanding the way financial transactions drive physical and information process flows. Great emphasis is placed by the whole enterprise on tracking financial information and transactions. Thus, information systems and flows are generally created to support the tracking of financial transactions. Physical processes are then subject to how information will be gathered surrounding financial transactions at each step along the process. Therefore, optimizing physical processes requires understanding information flows tied to financial transactions.

Using COMMWIP to eliminate waste

A valuable framework taken from the lean manufacturing concept is helpful in improving processes through the elimination of wasteful process steps. The framework, developed by process engineers in Japan and adapted to process improvement in the U.S., is called "COMMWIP." COMMWIP is a list of seven types of waste commonly found in production processes, as seen in the table below. We adapted the COMMWIP framework to apply specifically to warehousing processes, thus allowing us to more readily identify wasteful processes and process steps.[13] Operations managers should train employees in such a framework that they might see more readily areas of improvement in their own areas of work.

7 Forms of Waste	Example of Waste	Warehouse Equivalents
1. Correction	Redoing a report, repairing a part or redoing a service	Correcting the process to eliminate correcting orders or problems. Root-cause analysis to craft quality processes instead of quality through additional inspection
2. Over-Production	Running unneeded copies	Receiving, Putting Away, Picking, Packing, Shipping scrap or obsolete materials or materials of no value otherwise
3. Motion	Taking more steps than necessary to complete a task	Reducing the physical travel distances of people in fulfilling their responsibilities
4. Material Movement	Material being routed through many steps	Reducing the number of product "touches" and the physical travel of material
5. Waiting	Waiting to do work or parts waiting to be worked upon	Material waiting in the staging area. Represents opportunities to reduce put-away cycle times. Also, people waiting for other steps in the process to be completed
6. Inventory	Old office or business supplies that no longer have value but are still being stored	Unnecessary levels of inventory (based on replenishment policies) and other excess material being stored, having financial implications
7. Procedure or Process	Redoing things because of a cumbersome procedure	Opportunity to standardize processes to ensure employees are able to support systems and to minimize mistakes created by "fly-by-wire" processes

Table 2: Lean methods applied to warehousing processes

[13] COMMWIP is a generic framework used by process engineers throughout the world. Descriptions of waste are provided by Michael Taubitz of General Motors from his article "An Organized Workplace the Foundation for Safety," at http://www.sti.com/lazzara/03_01.htm; warehouse equivalents were created by Brian Bowers

4.2.6 Cost

Eliminating waste creates financial value for enterprise

The goal of utilization in any business setting is to maximize the use of fixed assets to minimize per unit costs and to optimize systems to minimize per unit variable costs. The result of this goal is higher levels of Return on Equity (ROE), Return on Assets (ROA), and Return on Invested Capital (ROIC). At the highest levels of the company and on Wall Street, these measures are applied to assess the health of the business.

ROE pairs company success with operations performance

Let us consider for a moment the calculation for ROE, a common measure of a company's performance:

ROE = Profit Margin * Asset Turnover * Financial Leverage,

where

Profit Margin = Earnings/Total Revenue,
Asset Turnover = Total Revenue/Total Assets, and
Financial Leverage = Total Assets/Shareholder's Equity[14]

Looking at this equation, we can begin to see how the operations manager contributes to the overall financial performance of the firm. Profit margins are dictated by revenues minus expenses. Thus, lower costs along the fulfillment chain, including lower inventory costs, contribute profit to the bottom line.

Profit margins are impacted by a variety of costs

Of course, there are many different costs associated with warehousing facilities. A more complete list of operational costs includes:

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[14] Higgins, "Analysis for Financial Management," Irwin McGraw-Hill, Boston, 2001, pg. 35.

- Fixed Asset Facility Costs, including debt principal and interest payments and interest tax shields, and overhead if activity-based costing not applied
- Variable Labor Costs, including labor costs associated with the inbound and outbound activities of the facility, and the allocation of overhead if activity-based costing is applied in per unit terms
- Inventory Carrying Costs, which may or may not be a hybrid of fixed costs spread across inventory units, depending on how costing is assessed
- Service Level Maintenance
  - Other Customer-Associated Costs
  - Revenue Losses Due To Service Level
  - Expedite Costs

Asset turnover is impacted by facility costs

Asset turnover is a ratio of the earnings produced by the total assets of the company. A company like Dell Computer that has focused on assembly and has pushed inventory and factory assets back onto its supplier's balance sheets, is effectively increasing its asset turnover. Similarly, any company that can do more with less will improve its asset turnover.

Effect of leverage on ROE not indicative of business results

Last, with regards to leverage, an operation manager's decisions to expand a facility using debt will actually raise ROE as the returns of the company are measured across a proportionally smaller amount of equity. Because the effects of debt engage a different set of financial questions regarding capital structures, distress, tax shields, etc., we will not discuss here how to assess the effects of leverage on ROE. More appropriate measures such as Return on Assets (ROA) or Return On Invested Capital (ROIC) may provide operations managers with better measures of the impact of facilities decisions on company performance.

4.2.7 Cost Estimation

Understanding costs imperative to making operations decisions

Managers who understand the impact of operations decisions on ROE in the near and far-terms should be able to make better decisions for the long-run performance of the company. However, understanding the basic costs involved in an operation is more difficult than one might imagine. Because many companies have developed a multitude of disparate legacy financial systems, and because there are so many different costing methodologies, managers may struggle to access all of the relevant financial data needed to make financial decisions. Accessing financial data is especially difficult when considering the reverse logistics network, where supply networks and systems are put together ad hoc as products are returned, as opposed to being designed as we find in the forward production flow systems.

Using cost models to make reverse logistics decisions

Ideally, operations managers should know the full fixed and transactional costs of each product unit flowing through his/her operation. To better understand this concept and need, we look at the example of Dell Computer. In the Fall of 2002, a LFM Tiger Team worked with Dell Computer to understand the full costs of its reverse logistics network. A conceptual map of this network, consisting of field stocking locations across North America, can be seen below.[15]

[15] Bowers, Sargeant, Musso, Bergmann, LFM Tiger Team Final Presentation, "ASL Reverse Logistics Design—ECO Purge Cost Model," February 7, 2003.

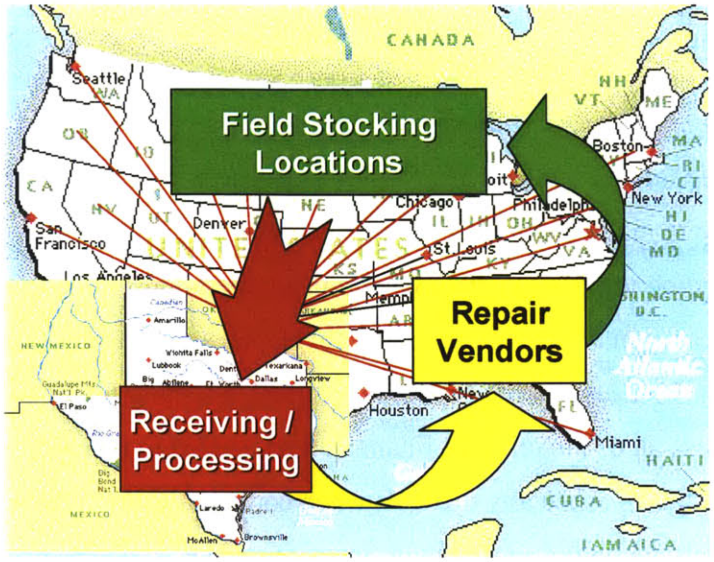

Figure 9: Reverse logistics network from field stocking locations to repair vendors at Dell Computer

Mapping reverse logistics network only a first step

Creating a reverse logistics map[16] was a first step for Dell in understanding costs associated with the logistics network. Second, the team assessed inbound transportation and logistics costs along each leg of the network, tracking products through a single 3PL's field stocking locations and hubs, and through internal warehouses and related facilities.

Cost analysis for creation of reverse logistics policies

Because contracts between Dell and its 3PL are based on per unit handling costs, estimations of reverse logistics expenses were much easier to calculate than in systems where multiple legacy systems employed. Assessing internal costs were more difficult to find, but Dell finance personnel were able to provide sufficient data for operations managers to estimate costs internally. Using this data, the Tiger Team was able to recommend reverse logistics policies that effectively considered customer satisfaction issues and costs.

Data makes customer satisfaction trade-offs more clear

These policy recommendations were opposite to the current thinking at Dell, mainly because the intuition that managers applied to the problem was not informed by financial data. In this

[16] Map represents Dell's basic reverse logistics network

instance, Dell managers were keeping defective inventory in the field because they believed that purging the inventory was very expensive. Customers were eventually experiencing quality problems as the defective material became installed at customer sites. Thus, Dell was the customer experience with bad quality for costs and service levels. When data confirmed that inventory purges were inexpensive, the policy was changed instructing managers to purge any time there was a quality problem with inventory in the field instead of impacting the customer experience and warranty costs.

Effective re-marketing depends upon accurate cost models

Cost modeling is crucial in order for operations managers to make good decisions. We will see the importance of cost modeling when we discuss re-marketing, where selection decisions are made about disposition of materials through various disposition channels.

5.0 Strategic Issues of Successful Remarketing Programs

5.1 Introduction of remarketing

Having discussed the key components of reverse logistics and the drivers and levers of facilities management, we are prepared to discuss remarketing. This research is focused on reverse logistics supporting remarketing programs, and spans remarketing business strategies as well as operational practices from different industries such as the consumer electronics, apparel, and auto industries; and different companies including Dell, Xerox, Nortel, Estee-Lauder, IBM, GE, and 3M.

5.2 Understanding remarketing strategies and reverse logistics practices

This section of the thesis provides insights into the issues of remarketing strategies and best practices with industry examples; and proposes ways in which supply chain, logistics, and operations organizations can best support remarketing programs. These insights should help managers grow and optimize any remarketing business, and at the same time better facilitate reverse logistics systems.

5.3 Highlighting strategic issues of remarketing

We have studied remarketing from top-level strategies to the box-level logistics operations. With regards to remarketing programs, there are several strategic issues, which if understood, could bring remarketing businesses a clearer focus and provide key partners additional direction and alignment.

5.3.1 Sustainable growth presents strategic challenges

The first of these strategic issues is sustainable growth. During the current difficult period of economic performance across the high technology industry, remarketing supported by reverse logistics has become a low-cost way for firms to create additional revenues. Technology companies, including small companies and startups, have capped their capital investments, thus reducing purchases of new instruments from equipment manufacturers like Agilent Technologies. Remarketing thus allows Agilent to reach these customers who need equipment but are not able to buy new.

The evidence of such behavior can be found in studying the growth of secondary markets during the post-tech boom years. Agilent's remarketing program has grown outperformed its growth targets by 30% this year alone. Because of this program, Agilent has been able to create new market segments and extract more consumer surplus throughout the entire high tech market.

5.3.2 Asking important questions of remarketing strategy

Key questions business managers should ask regarding general remarketing strategies include: Will remarketing businesses continue to profit manufacturers when the economy begins to turn around, or will remarketing sales cannibalize new equipment sales? Can we expect a remarketing business to be sustainable in the long run? How can remarketing drive revenue increases and cost reductions over time? These questions suggest study into several issues related to the remarketing business model, as discussed below.

5.3.3 Mitigating the business cycle via a scalable business model

Given the ups and downs expected in a remarketing business, the company should establish a scalable business model that provides sufficient flexibility for business cycles. Such a business model drives flexible operations based on dynamic product availability and customer demand. In the presence of uncertainty, a remarketing business should develop a flexible marketing staff, a robust product disposition model based on uncertainty, increased functional integration with product channels to enhance product availability information, and a low-cost flexible returns operation. In many cases, flexibility in operations will come from scaling labor at physical facilities to match needs. If sustainable growth is questionable, then a scalable business model—based on variable investments in handling capacity as opposed to fixed investments—will create flexibility for the remarketing business to continue to provide profitable returns for the company.

5.3.4 Capturing consumer surplus

In microeconomics, consumer surplus occurs where consumers would be willing to pay more than the current price. Market segmentation provides businesses the opportunity to capture consumer surplus from low-end to high-end consumers by setting different prices targeting their different customers. Remarketing programs work through product channels and auctions to capture revenues from low- and medium-end consumers.

5.3.5 Segmenting the high tech market

The key question is, could these programs capture additional revenues from customers by re-structuring product offerings, pricing and disposition channels? By studying the high tech equipment value chain and market, remarketing programs can further segment product offerings into different disposition channels, and maximize revenues. Such studies by companies should consider cannibalization, where high-end consumers who would be willing to pay new product prices are able to purchase equivalently performing products at a discount.

5.3.6 Understanding the true value of remarketable products

Remarketing programs create several positive benefits, including a more focused disposition of products. Through Agilent's remarketing program, for instance, Agilent managers get the final say on the disposition channel through which equipment enters secondary markets. To clarify, there are many different ways Agilent can dispose of its products, as seen in the table below. Once products are recovered, Agilent remarketers assess the value of equipments and parts, and direct this equipment to the channel of greatest value. For example, certain circuit boards create significantly higher value being refurbished and reused as service parts than being sold through auctions. Other equipment containing hazardous elements and chemicals are disposed of and recycled through a different channel.

Disposition Channels Available to Remarketing Managers

- Scrap at origin
- Ship to storage warehouse
  - Place in bin
  - Ship to test and measurement group (bypass option verification)
  - Ship to scrap (bypass option verification and put-away process)
- Ship to auction house (Based on past disposition and current inventory)
- Ship to tear down facility
- Ship to scrap (if there is not the capability to scrap at origin, Agilent wants to make sure they are disposed of properly – good corporate citizenship; or Agilent wants to assure these units aren't reused – miss future new unit sale,...)

Table 3: Disposition channels in Agilent's remarketing program

Assigning value using a disposition model

Thus, a remarketing program has the difficult responsibility of assigning value to products that otherwise would be considered worthless. The key question here is, which channel is the highest-value channel for this product? A comprehensive disposition model can provide decision support for disposition. Although the actual disposition models created and used at most manufacturers are proprietary, a list of Agilent's disposition channel choices (again refer to table above) can help you see how one could build a disposition model. A more comprehensive disposition model should include expected disposition channel revenues, shipping costs, carrying costs, remaining warrantable life of product, inventory aging data, and probabilistic decision trees.

The importance of cost data in the disposition model

Using cost data allows remarketing managers to determine the future date at which the product will have no value (given expected revenues)—at this critical point, the equipment should be scrapped or discarded regardless of any potential sales in the future. Without a thorough understanding of costs, inventory may be costing the program more than its worth. For example, one remarketing case showed equipment with a list price of $6,200 that had been on the shelf for 430 days! If the unit ever sold, it may only sell for 10 or 20% of its value. In the optimistic case of 20%, the unit will bring $1,242 of revenue. If logistics, storage, and transactions costs were well understood, we could know whether holding such a unit makes sense financially.

Disposition model should consider internal sales

Also, a disposition model allows remarketing managers the opportunity to assess whether or not the company receives greater value on internal or external sales. Re-use of certain key components may save the company millions of dollars per year, as is the case with IBM in Europe.[17] One tear-down program implemented only six months ago, aimed at recovering key components and parts for re-use, is already beginning to capture internal value for

[17] Fleischmann, et al., "Integrating Closed-Loop Supply Chains and Spare Parts Management at IBM," ERIM Report Series Research in Management, November 2002, pg. 4.

Agilent. Expansion of the remarketing program's tear-down offering could create additional revenues for the company.

Value of remarketing programs must be captured

In the case of internal sales, remarketing programs must develop a way to account for internal sales as part of a company's revenue assessment. Internal transfer pricing and transactions could provide remarketing and company managers with visibility to the cost savings the program is providing to the company, and provide a better basis for evaluating disposition decisions.

5.3.7 The threat of revenue cannibalization

Cannibalization of new product revenues occurs when remarketing products allow customers to purchase second-tier equipment at discount prices. At some point, remarketing may increase sales of refurbished equipment at the expense of the company's product groups. The degree of cannibalization occurring can be determined by gathering market information from customers and company product groups. Warranty and point-of-sale registration can help show which customers are purchasing which equipment, and how remarketing channel sales are impacting various product groups across which industries.

5.3.8 Revenue cannibalization as a competitive tool

The better remarketing managers understand their market, the more able they can use cannibalization as a competitive tool. This advantage occurs as remarketed products are focused on competitive product strongholds. The benefits of this approach are two-fold. First, revenues flow to the remarketing company instead of to a competitor. Second, the remarketing company increases its installed base and the likelihood that this same customer will purchase new products from this company in the future. This approach requires understanding customer preferences and competitor's product offerings and pricing structures. It also requires good, current market intelligence information.

5.3.9 Economies of scale and scope

The last strategic issue to discuss regarding the remarketing strategy has to do with economies of scale and scope, or the gains that occur as fixed costs are spread across unit volumes and as a central organization gains expertise in coordinating a myriad of different activities. Several questions regarding scale and scope include: Is the remarketing program the only program of its type within the company, or has each business unit developed its own program? If there are multiple programs, how much coordination occurs between them? Would it ever be possible for a single remarketing business unit to become a company's central remarketing program? How does one remarketing program's processes and capabilities compare with other business unit's remarketing programs? Which program has the greatest capability and competency? In summary, where are the opportunities to extract scale and scope economies?

Central returns center creates economies

In the case of Agilent, a business unit remarketing program and its associated logistics organization have both been on a course to develop expertise in product returns, remarketing, and reverse logistics. Two years ago, the logistics organization launched a regional distribution center to handle the worldwide reverse logistics for all Agilent returns programs. This centralized approach dedicates the logistics organization's capabilities and resources on handling all reverse logistics programs, and develops the organization's expertise in this area.

Maximizing economies of scale and utility of resources

Such a central returns facility is consistent with research of the best practices of cutting-edge companies. We hypothesize that because factory locations are focused on forward order fulfillment, factory managers do not have the time, resources, or process flexibility to handle the uncertainty and chaos of product returns. Observations made at factory locations show clutter and chaotic processes at factory receiving docks taking in returned products. For this reason, we argue that central returns facilities specialized in handling returns in their many shapes and sizes, and in their variable volumes and timings, will include more consistent, capable and robust processes and will reduce warehousing costs.[18]

[18] Rogers, Tibben-Lembke, "Going Backwards: Reverse Logistics Trends and Practices," Reverse Logistics Executive Council, 1998, pg. 50.

6.0 Operational Issues of Successful Remarketing Programs

6.1 Best practices of remarketing operations

Managers who have set in place a reverse logistics system capable of supporting a remarketing program should seek to understand the strategic implications of such a program, as discussed above. If such a strategy is a good fit for the company, then managers should begin to assess the operational practices associated with setting in place a remarketing program. In an effort to assist in this effort, this section discusses some of the high tech industry's best reverse logistics and remarketing practices. These examples are taken mainly from top related journal studies conducted at firms with leading programs, and from companies we would all recognize—Xerox, Nortel, 3M, GE, HP, Dell, etc. This discussion begins to provide remarketing and operations managers with ideas about how other companies are operating, and how such programs may be structured. This provides managers an opportunity to adopt best practices in some areas, and blaze new trails in other areas as needed, and also begins to provide visibility to how logistics groups can better support higher level program strategies.

6.1.1 Greater coordination of business operations

We should not be surprised that reverse logistics operations are chaotic. With so many options for how people can return goods and so many different products flowing back through reverse channels, we should expect more complications than in a traditional production supply chain. For example, see the reverse product flow for Agilent (see Appendix D). We see that products are being recovered all over the world through five major channels. This network engages both internal and external service providers and intermediaries.

In fact, research suggests that remarketing businesses require a greater degree of integration across the supply chain than forward order fulfillment businesses, including more intra-organizational or shared processes inside the company, and involvement from a new set of partners in the supply chain (namely material recovery organizations and e-marketplace intermediaries)[19]. This suggests that remarketing programs will be most successful as managers identify and incorporate various key players into program strategies and planning. The strategy must be clear and the program must align these key players to its objectives and plans.

6.1.2 Closed loop supply chains

Academic literature describes "closed loop supply chains" as a best practice. This type of supply chain is one in which the Original Equipment Manufacturer (OEM) maintains control of the product from outbound distribution to end-of-life disposal. The development of this type of supply chain originates primarily in Europe, where environmental policies require companies to take all responsibilities for the proper disposal of their products. Closed loop means that the product continues to cycle back to the OEM and through OEM distribution channels, without circulating into "gray market" and other secondary market channels. The diagram provided below demonstrates a closed loop supply chain for a GE refrigerator business.[20]

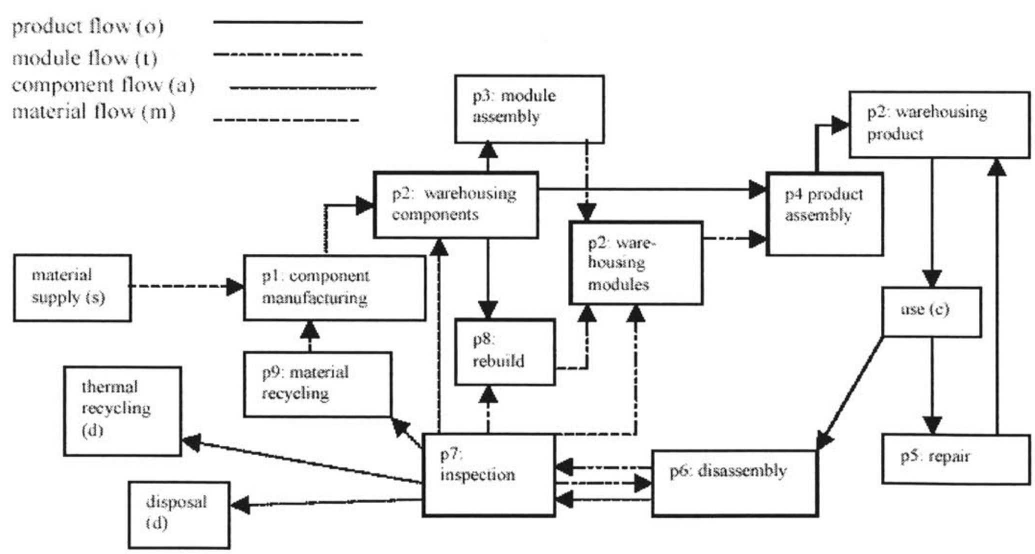

Figure 10: OEM's maintain control of products through a closed loop supply chain

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[19] Hillegersberg, et al., "Supporting Return Flows in the Supply Chain," Communications of the ACM, June 2001/Volume 44, No. 6, pg. 79.

[20] Krikke, et al., "Design of Closed Loop Supply Chains: A Production and Return Network for Refrigerators," ERIM Report Series Research in Management, August 2001, pg. 7.

Closed loop supply chain provides greater market power

For a company like Agilent, establishing a closed loop supply chain means Agilent has final say on the disposition channel through which equipment exits the market. Channel control is important in maintaining intellectual property of proprietary technologies and for increased access to essential boards and modules for re-use. Closed loop supply chains also give Agilent greater market power by controlling the availability of its very high-end, high quality, and high performance products. Also, similar to the Ford transmission story discussed previously, a closed-loop supply chain provides maximum revenues back to Agilent in the remarketing of used/refurbished equipment.

6.1.3 Enablers for designing a closed loop supply chain

Several enablers must be in place in order to establish a closed loop supply chain. Many companies and logistics organizations have developed some of these capabilities as part of their forward distribution systems; additional or complimentary systems will take time to develop as part of an overall strategy. Below is a listing of the key information systems needed by operations managers to design and manage a closed loop supply chain.

Notice, there is a difference between designing a closed loop supply chain and design for supply chain as referenced by many authors. Design for supply chain generally refers to an engineering initiative in which engineers consider supply chain issues while they are stepping through product development stages. For instance, Dr. David Simchi-Levi in his research on Design For Logistics (DFL), cites three key components vital to DFL, namely: Economic packaging and transportation, concurrent and parallel processing, and postponement/delayed differentiation[21]. There is an enormous benefit to DFL-type activities, because most of the cost of the product is associated with design decisions that trickle down to manufacturing and operations. Our concern in this research is, however, to discover and disseminate approaches and information essential to designing a remarketing program and its supporting reverse logistics system. Although we will not discuss product design here, managers should be think about ways in which product design could benefit their remarketing programs.

[21] Simchi-Levi, "Designing and Managing the Supply Chain," Irwin McGraw-Hill, Boston, 2000, p. 177.

6.1.4 Recovering products using product lifecycle information

Operations managers designing reverse logistics systems to support remarketing should consider the following questions with regard to the product life cycle.

Product tracking

Who bought a new unit and when will they be done with it? This information should be available from marketing organizations and provides the remarketing program with an understanding of the company's product base and product availability in the near term. Customer information provides contact information for product availability. Estee-Lauder uses an extensive tracking and tracing system to track product life cycles at retail locations because of product degredation and expiration dates[22]. Abstracting this example to high tech, we see that forward order fulfillment systems exist that can be used to provide important reverse logistics data.

Supply estimation

What does the installed base look like? How many available units are in the field and at any given location? This information can help the remarketing program target customers for Trade-In/Trade-Up discounts or other discounts in order to get back units that are in high demand on the refurbish market. This also provides Agilent field service representatives with additional maintenance information and opportunities to promote new products and/or services.

Quality information and tacit knowledge

Information regarding customer satisfaction and quality could be included in product group Customer Relationship Management (CRM) software to ensure that tacit information collected in the field by service representatives could be passed on to product groups.

[22] Brito, Flapper, Dekker, "Reverse Logistics: A review of case studies," Econometric Institute Report, May 2002, p. 16.

Incentives in the product channel lead behavior

In the Agilent example, most remarketing equipment comes from off-demo and off-lease channels. With this as a given, how can processes be improved to further provide market power to Agilent during periods of high demand on certain products? How are third-party vendors and lease service providers incentivized to keep Agilent's interest first? Are their marketing teams creating a gray market that competes with Agilent's core business? These are all important questions to consider with regards to Agilent's reverse supply chain. Agilent's reverse supply chain lanes are arguably the most vulnerable part of the remarketing system, and the largest barrier that keep the supply chain from being a closed loop supply chain.

Means and methods for product recovery

How can a remarketing program ensure that customers will give them back the product at end of life? And which products does the company really want back? These questions point to several tactics employed in other industries for getting parts and equipment back, including:

- Built-in refundable deposits—the auto industry extensively uses refundable deposits, or "core charges" as a means of getting back parts with high remarketing value. The core charge is built in to the price of the product, and is refunded once the original product is returned to the company. In the transmission example discussed in section three, Ford utilizes core charges to incentivize customers and dealers to return used transmissions once they have been replaced. Autozone or Checker Auto Parts provide core charge refunds when a car owner returns a used battery or alternator. A similar method is used in high tech for equipment with high value/re-usable IC boards. Reimbursement transactions are simple for customers and are facilitated through a returns center.

- Warranty bundling—company trade-in/trade-up programs are a huge step forward in creating a closed loop supply chain. Further integration of this type of program into warranties or into agreements made at the time of the product sale lock in the recovery of certain products.

6.1.5 Developing services to get products back from the customer

What does the customer actually do with the product when an upgrade arrives? How does a remarketing program help customers get the old product from the installation point to a shipping point inside the customer's site? Further, how does the remarketing program help customers actively ship back used equipment? HP has been working on this problem for many years. With the high value of HP's toner cartridge re-manufacturing programs, HP has made many efforts to recapture as many cartridges from customers as possible[23]. Methods included:

- Internal recycling programs—HP establishes recycling points within the customer site, and works to have the customer's office staff and administrative assistants be responsible for collecting used cartridges.

- Third-party collectors—HP also contracts with FedEx to work inside of the customer's site to collect HP printers, cartridges, and computers and to return them directly to HP. FedEx employees have actually worked with center managers to arrange pickup of used equipment, rather than letting the equipment stack up in the office spaces[24].

Although some company's products are not as recyclable as printer toner cartridges, collecting these products at end of life is a valuable service and could mean the difference whether or not a remarketing program has products available during a period of high demand.

6.1.6 Controlling returns: bringing order to chaos

Variation plagues industry remarketing programs. Troublesome variation occurs at the intersection between customers and returns organizations. For instance, multiple customers

[23] Interview with Mike Maurer, Agilent GTLS Logistics Manager, on HP Practices, January 9, 2002.
[24] Ibid.

interfacing multiple carriers interfacing multiple returns centers creates a multitude of directions for customers to return products, resulting in mass confusion on receiving docks, ballooning problem-receipts queues, and extended turnaround times and availability lead times. Returns in this case may refer to either customers returning products recently purchased or to reverse suppliers feeding products back to remarketing program centers. Reducing variation in supply channels, then, is a best practice relying on a remarketing program's ability to control the returns themselves. To combat variation, Rogers, et al. recommend several key reverse logistics management elements, as seen in the table at the below[25].

• Gatekeeping • Compacting Disposition Cycle Time • Reverse Logistics Information Systems • Central Return Centers • Zero Returns • Remanufacture and Refurbishment • Asset Recovery • Negotiation • Financial Management • Outsourcing

Table 4: Key reverse logistics management elements

Of the key management elements in the table, we specifically see the establishment of central returns centers as crucial to bringing control and order to the chaos of remarketing supply chains. Additionally, a central return center serves to compact disposition cycle times and consolidates financial management.

6.2 Is consolidating operations into a central returns center the right thing?

Before we discuss the advantages of a central returns center in-depth, we should discuss several issues for managers to consider with regards to establishing such a center. Depending on the issue, there are several cases in which it may not make sense for a

[25] Rogers, Tibben-Lembke, "Going Backwards: Reverse Logistics Trends and Practices," Reverse Logistics Executive Council, 1998, pg. 208.

company to establish a central returns center. In its most basic construct, a central returns center represents the consolidation of warehouse facilities and expertise into a single space dedicated to serving the reverse logistics system. Depending on the location of repair/refurbishment facilities, customers and recovered product suppliers, there may or may not be a substantial business case for establishing a single returns center. Managers should evaluate the movement of materials and conduct optimization studies of the reverse logistics network, just as they would in managing a forward supply chain. This type of study provides conclusions on whether a significant business case can be assembled to justify the expenses of such a center.

6.3 Considering the trade-offs of a central returns center

The trade-offs between these logistics costs and consolidation benefits can be examined through optimization studies, financial analyses, and consideration of the advantages and disadvantages of such a system. Managers should be able to quantify the costs of the reverse logistics network and the payouts associated with establishing a central returns center or centers. We warn managers to watch for tell-tale signs of consolidation disadvantages, especially multiple touch points in the reverse logistics network. Consolidation in the instance of Polaroid created multiple touch points in the returns system and caused such high return costs that it would have been better for store clerks to throw the products away instead of returning them.[26] For this reason, managers should seek means of reducing touch points in the reverse logistics system. Aside from this warning, we suspect that in most cases in the high tech industry, profit margins will substantiate going forward with some sort of consolidated returns center strategy.

6.3.1 Considering the benefits of control via a central returns center

Before making a final decision on establishing a central returns center managers should also consider the advantages of such a center as it supports the reverse logistics system. A central returns center provides several advantages over multiple returns sites, including carrier management, supplier management, processing economies of scale, an exclusive business

[26] Story related by Dr. Abbott Weiss, former VP of Worldwide Logistics for the Polaroid Corporation

charter and focus, and reverse logistics cost consolidation. Let us examine each of these advantages:

- Carrier management: A single returns center allows the remarketing program to manage all reverse logistics accounts through the same transaction system at the same location. Ideally, the company and the remarketing program's central returns center would contract with a single carrier for the transport of both primary and remarketed goods, thus simplifying the network and operations.

- Customer and supplier management: A single returns center creates a consistent message to customers and other suppliers of recovered products regarding correct shipping procedures. Product returns standards are communicated to customers from a single point of contact, thus simplifying customer interactions with the remarketing program and allowing the center to address problems more directly.

- Processing economies of scale: The receiving docks and personnel of a central returns center are equipped to handle returns of every type. As volumes increase, experience and process improvements create learning curve effects that drive down receiving process times and overall reverse logistics costs. A central returns center allows disparate types of returns to be processed in a standard way, thus optimizing receiving, put-away, pick, pack, and ship processes.

- Exclusive business charter and focus: As we mentioned early in this thesis, lack of clear ownership and responsibility is a key problem for reverse logistics systems. Having one group performing the handling of returns for the remarketing program at a central returns center creates a clear understanding of responsibilities and accountability. The performance of the reverse logistics system is measured against larger operational objectives. A clear charter allows both the remarketing program and the logistics center to establish expectations in a partnership to create the greatest value for the company, and allows the center to act proactively on behalf of the remarketing program. A single focus allows the center to develop and maintain expertise in the handling of returns for the remarketing program.

- Reverse logistics cost consolidation: A central returns center serves to bring all reverse logistics activities to one point, thus eliminating multiple redundant facilities in the reverse logistics network. Because of a remarketing program's multiple suppliers and supply channels, the central returns center seeks to receive material at the earliest available opportunity. In the case of Agilent's off-lease supply channel, the remarketing program knows which units are coming off lease and accepts shipments directly from the supplier anywhere in the U.S.[27] The central returns center and remarketing program should work to create similar such agreements with suppliers in other supply channels in order to assure timely receipt of the equipment, thus speeding product availability.

6.4 Compacting disposition cycle times

One operational way for a remarketing program to increase its product value and to reduce program costs is to reduce the time it takes for products to reach a disposition channel. Remarketing programs face several issues regarding the timing of disposition. First and most important, is the timetable for warranties. A product remarketed under a remarketing program should have a reasonable amount of service life left in order to be considered for resale.

6.4.1 Long disposition cycles shorten a product's useful life

If a product sits in storage so long that its useful life makes it ineligible for resale, then it cannot be resold, and has to be disposed of at a fraction of its value via auction or teardown. Thus, assuring that products are inside their service life creates value for the remarketing program. Therefore, speeding products through the reverse logistics and disposition systems is crucial.

[27] Interview with Donna Bonn, Agilent remarketing logistics liaison, regarding Off-Lease supply channel, July 2002.

6.4.2 Long disposition cycles mean products accumulate costs

Another reason for speeding up the remarketing process is that the product value is eroding daily due to operational costs. Although we have discussed cost in prior sections, understanding costs becomes essential as we consider disposition cycles. In examining the cash flows of a remarketed product, the scenario may look like the chart below as applied to Agilent's remarketing program. Notice that revenue flows are based upon the distribution of outbound products to each channel and the average value of each channel. Also, note that holding costs accumulate over time.

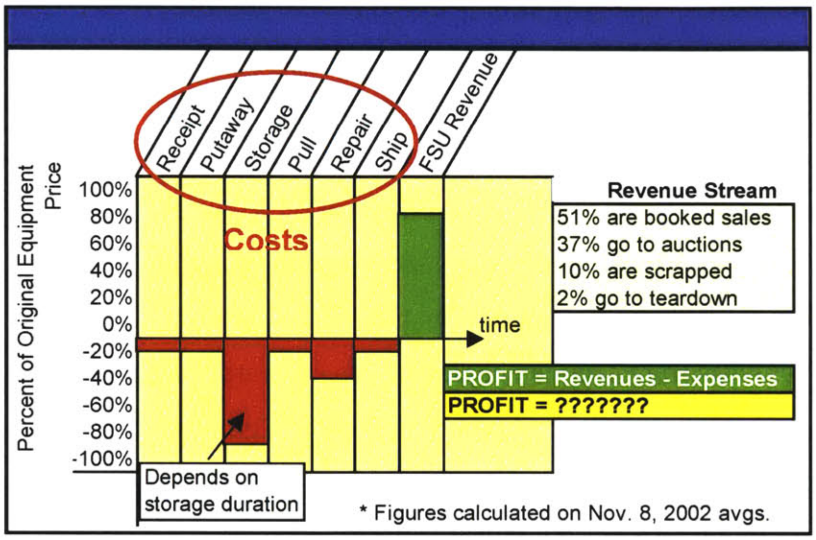

Figure 11: Cash flows of the Agilent remarketing system

Disposition cycles also affect the inventory turnover and ROE

Additionally, long disposition cycles reduce inventory turnover, and as discussed earlier, reduce business performance (as measured by ROE). When disposition cycles are long, company capital and space is tied up supporting a limited product offering. More inventory turns suggests greater utilization of space and a more extensive product offering.

Disposition trade-offs include lost sales opportunities

However, speedy disposition may also cost a remarketing program in the form of lost sales opportunities. Holding products for an extended amount of time provides the remarketing group with more opportunities to find customers willing to pay higher prices for the products, as opposed to sending the products to the auctions. Without sophistication in assessing the true costs and opportunity costs of disposition options, the remarketing programs may be left to maximize product availability by ballooning inventories for potential sales, or may speed disposition too aggressively and pass over opportunities for sales.

6.5 Decision tools are crucial to successful remarketing disposition

The above issues highlight the remarketing program's need for a set of decision tools to make its critical disposition decisions. Each of the following decision tools builds on a previous tool. Thus, the tools go from the most basic information to the most refined modeling for disposition and operations decisions.

6.5.1 Cost models serve as foundation of decision tools

At the foundation of any decision tool are accurate financial cost models. Under- or over-stating the costs of any single component of the operation will cause the remarketing program to make poor disposition decisions and to create marginal policies. These cost models should include the following information:

- Logistics costs from suppliers to central returns warehouse facility
- Receiving costs, including receiving, testing, and put-away
- Any additional costs associated with problems receipts
- Daily carrying costs per bin in warehouse
- Move costs to repair
- Repair costs per unit
- Outbound packing and shipping costs

6.5.2 Probabilistic models provide greater accuracy

Building on the foundation of cost models, remarketing programs should begin to forecast demand and product sales based on distributions or probabilistic models. Such probabilistic models should be created with the following factors in mind:

- The frequency of products flowing through each disposition channel to create expected values on a given sale based on which channels it will be sold through.
- Product life cycle stages per product, geared toward anticipating and understanding demand patterns based on the stage in the life cycle of any given product.

- The distribution of disposition life cycles for various products to provide an estimate of how long the expected storage length will be for the product.
- Tracking information used to determine, estimate, and even solicit arrivals of products from the multiple inbound channels available from the remarketing program. The program should know what products will be flowing from off-lease and off-demo channels, because the retirement of equipment in these channels is well known ahead of time. Refinement of channel supply models helps even out spikes in supply, or creates more refined expectations for program and reverse logistics staff.

6.5.3 Disposition models take inputs from previous models

Once cost models and probabilistic models are in place, remarketing programs can use these models to make disposition decisions. With this information, program managers could determine if holding a unit in storage for a longer period of time would capture more revenues; alternately, managers could determine, based on cost and revenue projections, a point at which holding the unit any longer costs the company money. By perfecting the disposition model, remarketing programs maximize program revenues and minimize losses to the business.

6.6 The importance of information and communication technology

In addition to these various models, best practices suggest that other information and communication technology (ICT) can help coordinate the activities of a remarketing business and reverse logistics operation. In the diagram below are several examples which have come through the research of Brito, Flapper, and Dekker, working with companies such as Xerox, Nortel Networks, and Estee Lauder (concerned with expiration dates on consumer products)[28]. Such systems could be developed on company ERP platforms or via other solutions as deemed necessary by the program.

[28] Brito, Flapper, Dekker, "Reverse Logistics: A Review of Case Studies," Economic Institute Report, May 2002, pg. 18.

ICT Tool	Requirements	Assists	Life path phase
DSS for end-of-use; (Nagel and Meyer, 1999)	Info. on operations' costs & recycling revenues	Cost optimization, facilities location, vehicle routing, etc.	Supply Chain Loop
Computer's configuration reader (Nagel and Meyer, 1999)	Info. on operations' costs & recycling revenues	Setting buy-back price;	Customer
Software specialized on return handling (Meyer, 1999)	Product's expiration data, damage check	Recovery-related decisions	Supply Chain Loop
DSS for remanufacturing (Linton and Jonhson, 2000)	In-depth information on processes	Remanufacturing-related decisions	Supply Chain Loop
DSS for warehousing (Landers et al., 2000)	Real-time data on orders, info. on capacity restrictions	Inventory control, transportation's choices, etc.	Supply Chain Loop
DfX, remote maintenance, etc. (Maslennikova & Foley, 2000)	Extensive data-base on products	Recovery options, environment's sustainability, and so forth.	All phases
DfX (X=Recyclability) (Farrow et al., 2000)	Further separation of resins; Technological innovation;	Developing a 100% recycled Kayak.	Supply Chain Loop

Table 5: ICT Tools, Requirements, and Benefits for Reverse Logistics

6.7 Expanding remarketing into financial services

The last area of the remarketing program to highlight is the areas of financial services. This serves as one more way in which the use of an effective reverse logistics and remarketing program serve to capture additional profits. Implicit in many remarketing programs is the opportunity to finance customer purchases of expensive equipment. Just as in sales of new equipment, providing financial services for customer purchases of remarketed products provides remarketing programs lucrative opportunities to garner additional revenues and capital. A most noteworthy example of this can be found in the aircraft industry, where GE not only expanded its opportunities to service, repair, and remarket jet engines[29], but also involved GE Capital in providing financing for GE's jet engines. Over time, GE Capital has become the chief financier for customers purchasing entire Boeing and Airbus aircraft, owning or managing aircraft for airline companies around the world.[30]

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[29] Murman, Bozdogan, Nightingale, et al., "Lean Enterprise Value," 2002, Palgrave, New York, p. 20.
[30] GE Capital Aviation Services, "GECAS Places Largest Widebody Order in its History for Boeing 747 Freighters and 767's," GE Capital Aviation Services news archive, December 15th, 1999, http://www.gecas.com/News19991215.asp

6.7.1 Financial services allows product tracking and first rights

Aside from additional revenues, being involved in financing activities provides the re-marketing program better opportunities to track products through the supply chain, and to enforce more closely a closed-loop supply chain concept. This also gives program managers first rights to products coming back into the marketplace in default situations, as opposed to other lending institutions which may dump high value products onto the market at steep discounts.

7.0 Lean Enterprises and Customer Value

7.1 Reverse logistics and remarketing set in context of Lean operations

In the previous sections, we have established a case for the use of reverse logistics—an activity in which many companies are already involved involuntarily—as a competitive tool in generating revenues. We have discussed the strategic and operational benefits and issues of establishing such systems. We have established key differences between forward and reverse logistics systems. We have brought to light discussions of these systems taking place in operations meetings and academic literature around the world. One important thing remains to be done in this section—to provide the reader with a context in which logistics systems are operating today. The context in which logistics systems operate today is lean operations, focused on maximizing customer value and minimizing costs. The following definition provides additional insight into the intent of lean operations:

> "Lean thinking is the dynamic, knowledge-driven, and customer-focused process through which all people in a defined enterprise continuously eliminate waste with the goal of creating value."[31]

7.2 Applications of lean thinking in product and service organizations

"Lean thinking" is impacting many different types of organizations around the world. In mining operations, manufacturing facilities, machine shops, design firms, governments, hospitals, insurance companies, and grocery stores, managers are implementing and refining lean principles. These principles, spanning supplier relationships to inventory management to factory floor processes to business process re-design, have created significant advantages for the companies implementing them. In the logistics space, managers have honed lean principles to perfect forward order fulfillment cycles and forward inventory management (commonly reaching 98%+ service levels).

[31] Murman, Bozdogan, Nightingale, et al., "Lean Enterprise Value," 2002, Palgrave, New York, p. 90.

7.3 Managers engaged in enterprise thinking avoid designing in functional silos

Certainly, viewing an organization in isolation would understate the opportunity and difficulty of creating value for the larger enterprise, whether we define "enterprise" as multiple programs or functions within the same company or the members of an entire value chain. Unconsciously, many people consider the broader set of stakeholders when they perform any task or function; however, under pressures and deadlines managers sometimes retreat to functional silos, thus sub-optimizing the performance of the larger department or company. As managers seek to design remarketing and reverse logistics systems, they should engage in "enterprise-centric" thinking, or consideration of a wider range of stakeholders, to ensure that performance is maximized and that resources and time are not wasted.

7.4 Lean enterprise represents the entire customer value chain

At the highest level, the enterprise is the value chain responsible for delivering products and services to customers. By viewing the enterprise broadly, we seek to consider all of the stakeholders contributing to a product's success in the market. Most importantly, an enterprise is focused on delivering value to customers. The Lean Aerospace Initiative, a MIT consortium focused on studying and understanding lean enterprises, makes a distinction between the core enterprise and the extended enterprise helpful to our supply chain design efforts:

> "The core enterprise consists of entities tightly integrated through direct or partnering relationships. Less tightly coupled customer, suppliers, and government agencies encompass the extended enterprise – all the entities along an organization's value chain, from its customer's customers to its supplier's suppliers, that are involved in the design, development, manufacture, certification, distribution, and support of a product or family of products. Products include all of the goods and services that satisfy the customer's, and ultimately, the end-user's needs."[32]

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[32] Murman, Bozdogan, Nightingale, et al., "Lean Enterprise Value," 2002, Palgrave, New York, pg. 163.

7.5 Supply chains supporting the lean enterprise focus on customer value

Descriptions of the core enterprise and extended enterprise are helpful in designing supply chains to meet certain objectives. Notice how the purpose of the enterprise is to satisfy customer and end-user needs. We can see that managers should be engaged in designing products and associated supply chains in the most effective ways to meet customer needs. Thus, the most effective products and supply chains are those designed to provide system-wide benefits for all stakeholders.

7.6 Designing supply chains for the lean enterprise is a non-zero sum activity

The key point of enterprise thinking is that the objective of designing supply chains to enhance the lean enterprise is not totally self-serving. The objective is to eliminate waste and create value along the entire value chain to maximize value to customers. Thus, the challenge for managers is to find ways to create non-zero sum gains for enterprise value chains[33].

7.7 Good design leads to waste reduction in entire value chain

In creating such gains, managers have many alternatives at their disposal. Further, managers choosing lean as a method of creating non-zero sum gains for their companies and value chain recognize several universal principles of lean, namely:[34]

- Waste minimization
- Responsiveness to change
- Right thing at right place, at right time, and in right quantity
- Effective relationships within the value stream
- Continuous improvement
- Quality from the beginning

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[33] "Non-zero sum" is a term used in this context by Dr. Jonathan Byrnes; his comment was taken from MIT 1.261J course: Case Studies in Supply Chain

[34] Murman, Bozdogan, Nightingale, et al., "Lean Enterprise Value," 2002, Palgrave, New York, pg. 147.

7.8 Highlighting the benefits of lean enterprise design

These lean principles highlight the thinking that should be applied to designing business models and supporting supply chains. When we see these principles in practice, we see integration of information and process knowledge across value chains, resulting in more stable and interpretable demand signals, better value propositions for customers, and significant reductions in product cycle times and inventory levels.

7.9 Effects of lean enterprise design on inventory levels

As Dr. Jonathan Byrnes states, "The amount of inventory in a company is a result of management capability."[35] In other words, strong management understands the issues of the enterprise and is able to manage accordingly. Stronger managers will see ways to eliminate inventory buffers by creating more robust mechanical and people systems, and cross-company supply chains. In many cases, effective managers will use principles of lean as a systematic approach to creating these more robust systems.

7.10 Benefits of supply chain design focused on the lean enterprise

So how, exactly, does supply chain design enhance the lean enterprise? As we study remarketing and reverse logistics design, we see that each of the pieces of the value chain is a contributor to the overall enterprise's effectiveness in meeting customer needs. The various connections are outlined below:

Remarketing and reverse logistics design enhance the lean enterprise by:

1) Providing value to a new customer base through expanded market segmentation of customers who cannot afford new equipment
2) More effectively handling customer returns and/or product disposition and thus improving customer satisfaction and loyalty
3) Providing value to companies through the re-use of goods and services. Additional revenues are captured on existing products without having to send them through the complete manufacturing process
4) Minimizing wasted materials and time in the manufacturing of raw materials

[35] Jonathan Byrnes, comment taken from MIT 1.261J Course: Case Studies in Supply Chain

5) Reducing lead times for internal and external customers who are seeking parts and components that are otherwise difficult to obtain due to manufacturing complexity
6) Linking disparate value chain players in a coherent manner, thus creating a supply chain analogous to the forward distribution channel
7) Bringing order to the reverse supply chain, thus optimizing processes in the reverse logistics network that are otherwise chaotic

7.11 Reverse logistics networks don't come without a cost

Having articulated so many benefits, we must also examine the costs of a remarketing program and reverse logistics. These costs come in the form of information systems improvements, receiving process improvement, process re-designs, and dedicated space demands. Information systems must have capabilities to track products in the reverse supply chain. This information is in turn used for planning and scheduling purposes.

Receiving dock process improvements may include hiring additional workers and building systems to track problems receipts and to assist in product identification (wherein some products show up without any identification). Process improvements could also include process-redesigns to eliminate waste in the system. Last, improving the receiving process includes improving linkages in information systems managing financial transactions. The order of such transactions and systems many times dictates the physical flow of products. Transactions can be re-designed and systems linked to facilitate better process design.

Developing dedicated spaces for reverse logistics may mean utilizing an existing space or may require opening a new warehouse. Either approach may increase costs for a logistics group, but will enable better management of the overall remarketing effort. As you can see, these improvements don't come without a cost, which are different for every reverse logistics network and every remarketing program.

7.12 Reverse logistics networks create new levels of complexity

Seeing the benefits and costs sited above, we can see that remarketing and reverse logistics design actually create new levels of complexity for firms. As we have already demonstrated, the supply chain networks used to support a remarketing program are substantially different than those used to support production and forward distribution. The players are much more loosely coupled, and thus require greater degrees of coordination. Further, because the return of products through reverse logistics channels is in many cases unpredictable, supply sources to remarketing programs are less predictable. Therefore, demand for remarketed / refurbished / discount goods is much more difficult to fulfill.

7.13 Lean principles in reverse supply chain design help mitigate uncertainties

However, designing reverse supply chains using lean principles serves to mitigate these uncertainties. McKinsey and Company's Operations, Strategy, and Effectiveness group sites four such principles for creating a lean process helpful to us as we consider designing supply chains. This lean design process establishes systems and processes to create: 1) Stability in demand and processes, 2) Balance and efficiency in the flow of products and services, 3) An operational rate at which all processes operate (TAKT), and 4) Demand pull by customers allowing firms to provide products as orders are "pulled."[36] Leveling demand, balancing flow, setting activities to a routine pace, and creating customer pull all serve to eliminate the uncertainties of fluctuating market demand and operational capabilities to meet that demand.

Another important activity in mitigating uncertainty is to develop a baseline understanding of how the current system works by mapping out information and product supply chains. This can help managers see products and returns as they become available as sources of supply. Such an inbound supply channel map for Agilent's remarketing program can be seen in Appendix D. This map shows how products in various channels can be tracked and predicted. Such mapping addresses the key design challenge of creating a system that has stable demand and demand that is pulled by the customer.

7.14 Reverse supply chain design: applying forward supply techniques

Designing reverse logistics supply chains gets us closer to some of the practices readily available in forward product distribution systems. For instance, MIT's Dr. Simchi-Levi

[36] Strube, Willats, "McKinsey OS&E Series: Manufacturing Practice Summary," McKinsey&Company, 2002, p. 36.

refers to one such practice known as "Risk Pooling," where customer demand is pooled or viewed in aggregate to minimize the amount of safety inventory carried to support order fulfillment.[37] Another practice of supply chain postponement can be applied to product dispositioning. Final refurbishment and test on product can be postponed until an order for those goods is processed, thus avoiding wasted time and effort on equipment that will not actually be sold. By designing reverse logistics systems, demand for certain products can be assessed in aggregate and to a greater extent inventory can be pulled from inbound channels or refurbished from stock more efficiently.

7.15 Operations managers responsible to apply effective design

Many other supply chain, logistics and planning methods practiced regularly in forward distribution systems can be applied in remarketing and reverse logistics systems if managers will consider methods for doing so. Many such practices are contained in the previous pages. Each of these practices and methodologies is aimed at integrating lean thinking into supply chain design to enhance the company and the extended set of stakeholders, or enterprise.

[37] Simchi-Levi, "Designing and Managing the Supply Chain," Irwin McGraw-Hill, Boston, 2000, p. 60.

8.0 Summary and Conclusion

This thesis provides a framework of strategies and practices program and operations managers can incorporate into remarketing and reverse logistics programs. These strategies and practices have been presented above and are too numerous to summarize here. However, it is valuable to review the reasons for which such programs develop and how these programs can be used to create a competitive advantage for companies.

8.1 Remarketing attracts revenues from additional customer segments

Due to faltering capital equipment budgets in most major companies during the recent economic downturn, high tech equipment manufacturers have faced falling sales and pressures to reduce costs. Remarketing of products, supported by reverse logistics systems, opens doors to existing customers unable to upgrade and to new customers who otherwise could not afford such equipment. Because this equipment comes back to the manufacturer virtually free through several different channels (trade-in, off-demo, off-lease, etc.), reselling this equipment provides extremely high profit margins compared to the forward manufacturing process.

8.2 Product recovery has implicit benefits

Remarketing requires product recovery, which benefits the manufacturer in several ways. First, the manufacturer is able to maintain better control over equipment prices in the market. Second, the manufacturer is able to determine which disposition channels bring the greatest value to the company, whether that is through tear-down for rare spare parts or through auction sales. Third, product recovery provides opportunities to fulfill corporate responsibility in terms of environment, as seen in many European companies today.

8.3 Remarketing requires appropriate supply chain systems

The most effective product recovery scheme occurs in what is called a "closed-loop" supply chain. Establishing such a supply chain requires implementing reverse logistics processes, systems, and partnerships capable of tracking and procuring equipment to meet customer demands. Effective reverse logistics supply chains will also include effective facilities management.

8.4 Remarketing and reverse logistics enhance the lean enterprise

All of these efforts are couched in the influence such programs have on the lean enterprise. By earning revenues on fewer assets and by reducing waste in both facilities and supply chains, we see that reverse logistics and remarketing programs enhance lean enterprises. And as these programs are implemented more efficiently and effectively, the greater value there is returned to the enterprise, the company, and the customer.

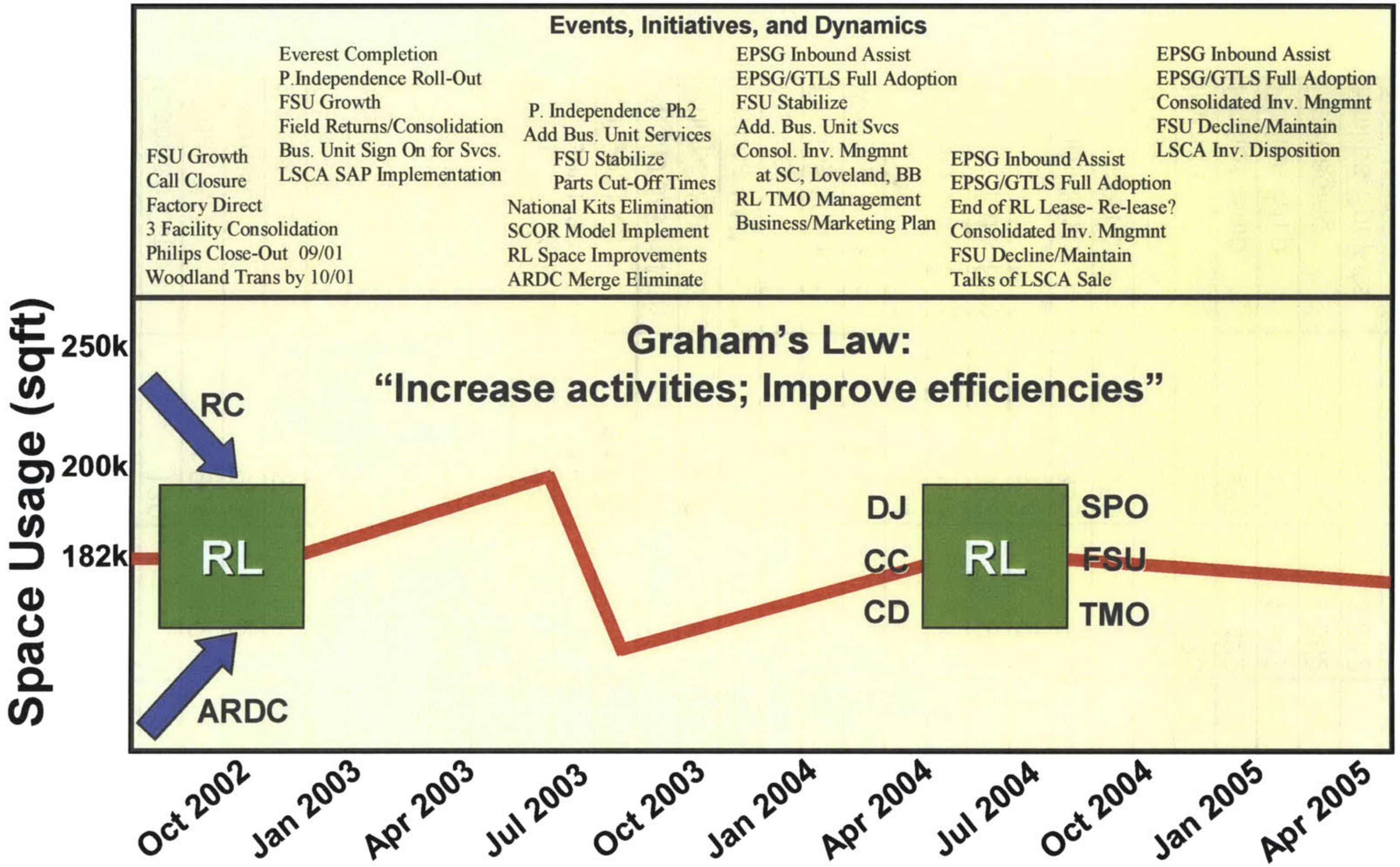
8.5 Improvement opportunities exist because most networks are not designed

The opportunities for growth and operational effectiveness in the reverse logistics programs are tremendous, mainly because the systems associated with such programs have never been designed. This thesis serves as a guidebook to operations, supply chain, and business program managers seeking to design and implement such programs. This research also serves to point out improvement areas for managers who are already involved in the lofty effort of reducing costs and maximizing value.

8.6 Future will hold greater complexity and segmentation

In the future, operations leaders will face mounting complexity as technology and process advances allow customer markets to be segmented ever more finely. The principles in this thesis serve to especially aid those managers working with customer segmentation happening around secondary and refurbished markets.

Three Year Plan For Continuing Operations



Appendix B—Warehousing Activities and Associated Square Footage

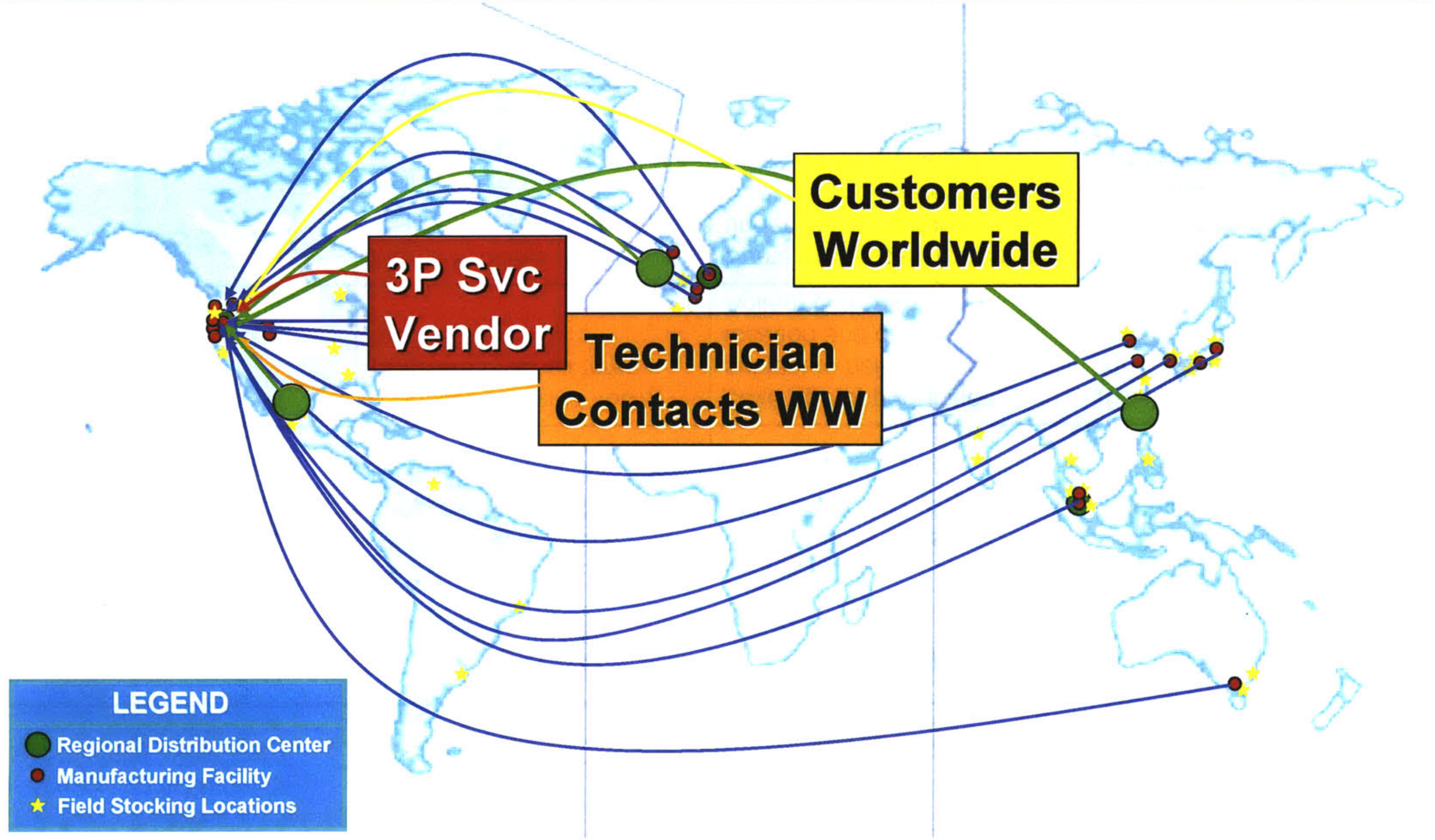
Space	Area	Philips	Agilent
Spectrum	4,937	4,937	
Office	3,476	869	2,607
Comtec Off	130	33	98
Break RR	4,964	1,241	3,723
Comtek	963	241	722
Exchange	11,570	2,893	8,678
Battery	2,709	677	2,032
FSU	6,717		6,717
DJ	6,485		6,485
Philips FGI	2,589	2,589	
Philips FGI	2,114	2,114	
Philips Rec	1,426	1,426	
Agilent Rec	3,445		3,445
Agilent FGI	34,787		34,787
Pkg/Dis/Bin Mtn	4,795	1,199	3,596
Philips SL	473	473	
Philips FGI	616	616	
Merge	4,334	1,084	3,251
Philips Vidmar	683	683	
Agilent Vidmar	4,669		4,669
Gov/QA	4,304	1,076	3,228
Agilent Bulk Shp	3,196		3,196
Philips Bulk Shp	957	957	
Ship Dock	3,634	909	2,726
Philips Ship	849	849	
Agilent Shp	3,859		3,859
Break Hazmat	3,276	819	2,457
Invoice	478	120	359
Philips Ship	422	422	
Philips Ship	1,447	1,447	
Packaging	5,408	1,352	4,056
Philips Fgi/Kits	3,812	3,812	
Agilent Kits	1,161		1,161
Misc	317	79	238
RR	144	36	108
Total	135,146	32,951	102,196

Consolidation Impacts

	Today	Tomorrow	Change
Customers	All business divisions supported except SPG. Plus CE's, FSU Program, Call Closure	Same customers supported before and after move	No Change. All changes should increase or maintain customer satisfaction
People	3 Supervisors and 160+ Employees for all three facilities	Leverage opportunities subject to being in the same location and on the same Agilent ERP platform	15% reduction in indirect and labor costs for ARDC and RC operations
Processes	Merge Process Hotline/Parts Distribution Call Closure Returns Receiving	Same processes, except all under the same roof; Streamlining processes & cross-training creates efficiency	Possible short-term process disruption; Long-term process improvement to maintain activities in RL space
Space	ARDC = 20% Utilized RC = 50% Utilized RL = 90% Utilized	5000 Sq Ft (Area) Opened Up by Philips Move	Move still leaves 2000 Sq Ft available without a re-design
Costs	Current Costs per Year for all three facilities = $3.424 Million	Costs per Year for integrated RL operation = $2.6 – $2.7 Million	Difference = $700k - $800k per year, or $1.4M NPV over three years

Inbound Flow Network to Re-Marketing Group

Off-Factory	Off-Demo	Customer Return	Trade-In/Trade-Up	Off-Lease



Appendix E—Results of Agilent Technologies Internship and Research

Agilent Background

Agilent Technologies was created when Hewlett-Packard spun the company off in 1999. Since that time, Agilent has been developing organization, information, and other business systems that allow Agilent to stand independent of HP. One of these important systems is Agilent's logistics network.

In 1999, Agilent's philosophy was to "copy and go" with HP's systems. Most of the HP systems were copied and executed in an effort to get Agilent's systems on line as soon as possible. These systems included a local Roseville logistics network of three warehouses, providing finished goods storage, product merging, and service parts returns. At the time, Agilent had all the advantages of HP's volumes and identity when dealing with clients and carriers in its logistics network. However, some HP logistics systems didn't make sense for Agilent's much smaller operations. Today in 2003, Agilent's own corporate identity and its business needs have become much clearer, allowing Agilent leaders to create a new path for the company.

Competitive pressures and a difficult economy have increased pressure for Agilent's logistics systems to maximize company value. Current measures by company leaders to change and optimize business systems include the implementation of Oracle's ERP solution. Along with Oracle, the opportunity today is one of developing a local physical logistics system that meets Agilent's needs at the lowest possible cost.

Problem Summary

Agilent's Global Trade Logistics Support (GTLS) organization, located in Roseville, California, was faced with the challenge of managing several different centralized activities, including support of a central parts business serving North and South America and a $300M remarketing program for Agilent's largest business unit. GTLS managers hired a research fellow from MIT's Leaders For Manufacturing program to assess the overall reverse logistics system with its associated warehouse facilities and to make recommendations and implement improvements.

Approach

The project was approached in two phases.

Approach to phase one: Assessing the reverse logistics facilities network
The objective of phase one was to understand and address the issues associated with the physical facilities supporting the reverse logistics network. Assessments of the facilities were made using an operational model developed for this purpose. Use of the model pointed to opportunities for cost savings through facility consolidation. Studies were undertaken to determine if facility space and operations would support short and long-term program

initiatives. Sensitivity analysis was performed to ensure requirements of internal customers could be met. A three-year plan was created to provide a more robust assessment of program needs. Financial models were created to assess costs and benefits of consolidation. Facility layouts were examined for "monuments" and other opportunities for improving the facility configuration. Warehouse utilization and inventory turnover were studied through hands-on audits and facility database analysis. Alternative methods of parts order fulfillment, including direct shipping and merge-in-transit operations were considered. Final recommendations for facility consolidation and other improvements were presented to management. Upon discussion and acceptance of plans, a cross-functional team (including members of the logistics team, facilities management, the IT organization, and the third party logistics provider was formed to implement changes.

Results of phase one:
Consolidation recommendations were implemented 100% on October 1, 2002. Savings to Agilent were predicted to be $3.0M with a net present value of $1.2M over three years. Upon completion of the project, materials freed up by the consolidation were re-used in a factory facility in Sonoma County, saving the company an additional $250K. The NPV of the project resulted in $1.4M in bottom line cash flow over three years. Additional benefits of the implementation included higher utilization rates at the consolidated facility; the removal of monuments through re-configuration resultied in less travel in the warehouse and freed up 8,000 sq. ft. of additional floor space.

Approach to phase two: best remarketing and reverse logistics practices
Starting in the summer of 2002 and continuing in the Fall 2002 and Spring 2003 terms, research was conducted to understand how Agilent's remarketing program could generate the maximum possible revenues given the current state of the economy. Benchmarking of best remarketing and reverse logistics practices was conducted via literature review and hands-on work with both the remarketing program and GTLS. Key issues quickly emerged, including the need for a cost-driven disposition model to assist in product disposition decisions. Also, inbound and outbound channel information was analyzed for the first time to provide focus to reverse logistics activities. Recommendations were formulated for improvement of the remarketing business and of GTLS's reverse logistics support of the remarketing program. These recommendations were presented to GTLS staff in August of 2002, and benchmarking results and recommendations were presented to the remarketing business unit president in early 2003. A site visit in January 2003 provided an opportunity to update business data and to formulate additional areas of study.

Results of phase two:
GTLS directors state that the recommendations presented to the staff and the business unit are being implemented. One of the key recommendations for the establishment of a closed loop supply chain will take time to implement, as different tiers of the supply chain become involved and engaged in the process. The disposition model presented has been updated several times and used on a preliminary basis to determine whether inventory should be held longer, scrapped, tore down for parts, or sold to online auctions. Further implementation of this model will occur over Summer of 2003.

Additional information

Below is additional information about the Agilent reverse logistics system and remarketing program, useful in understanding the context of the research fellow's project.

Examining current warehouses supporting the logistics system

Agilent has three primary warehouse spaces in the Roseville, California area. These warehouses, called "RL," "RC," and ARDC, serve several functions important to Agilent's overall logistics system. Below is a description of each facility and the activities taking place at each.

The RL Warehouse

The first warehouse, RL, is located near the large HP assembly facility on Foothills Drive in Roseville. The warehouse serves three main functions:

1) Service parts warehousing and shipping—parts are shipped from RL to field technicians (called Customer Engineers or "CE's") throughout North and South America conducting repairs at customer sites. Thus the warehouse holds a certain quantity of finished goods in stock and has IT infrastructure to accommodate orders and shipping.
2) Service parts returns and repairs—CE's return defective or damaged parts to RL for credit, similar to alternator core returns at an auto shop. IT infrastructure provides crediting process to specific organizations. Technicians inside of RL then repair or scrap defective parts and return them to the inventory racks for future use.
3) FSU Repair and Warehousing—The Financial Services Unit (FSU) Program allows customers to purchase new and repaired or refurbished parts from Agilent. The FSU program also provides customers with an option to "Trade-in and trade-up," again utilizing either new or refurbished parts. In either case, the parts are taken from the service parts or repair parts racks in the RL facility and shipped to the customers. The current FSU revenue goal for this year will be exceeded by 30%; thus, this program, as well as storage space, will continue to expand in the coming years.
4) Decontamination for Phillips Returns—Medical equipment that has been in contact with bio-medical materials is sent to the RL facility for decontamination. RL contains a 3,000 ft^2 facility with 20 technicians who perform the de-con procedures.

The RC Warehouse

The second warehouse, RC, is located in Rocklin (just north of Roseville). This facility provides two services for CE's in North and South America:

1) Warehousing and DJ for Phillips—Phillips Electronics has purchased the medical division of Agilent Technologies. Agilent is contractually committed to provide logistics support for the division until September of this year, at which point Phillips will assume all responsibility for the operation. The RC facility houses defective devices returned to Phillips. These defective parts are stored in racks

called the "DJ" or "Davey Jones" area, where they await disposition. Some returns have been in contact with bio-medical materials and are thus shipped over to RL for decontamination before being stored on the DJ racks.

2) Field Service Call Closure—Call closure is an in-field activity that has been brought together with warehousing facilities to be managed more efficiently. Currently, 18 employees work to receive, document, close tickets, and either put field returns on DJ Racks or send to RL for refurbishing or disposition.

The ARDC Warehouse

The last warehouse, the Americas Regional Distribution Center (ARDC), is located in Woodland, CA, about 45 minutes southwest of Roseville. This warehouse performs one main function, as described below:

1) Merging and Consolidation of Product Orders for the Americas—A small percentage of Agilent product orders require consolidation of finished goods inventory arriving from different parts of the world. For instance, an x-ray scanner built in Colorado may be shipped to the ARDC, where it is merged with its power supply, which was shipped from Malaysia. After being consolidated, the order is then shipped to Brazil to the end customer. By consolidating orders, Agilent pays the cost of one order shipment instead of several shipments; however, most orders are shipped directly to the end customer either because they are a one-piece order or because the separate orders are more cheaply shipped from the factory than shipped to the RDC and back out to the customer.

Appendix F—Reverse Logistics Supporting a Typical Supply Chain[38]

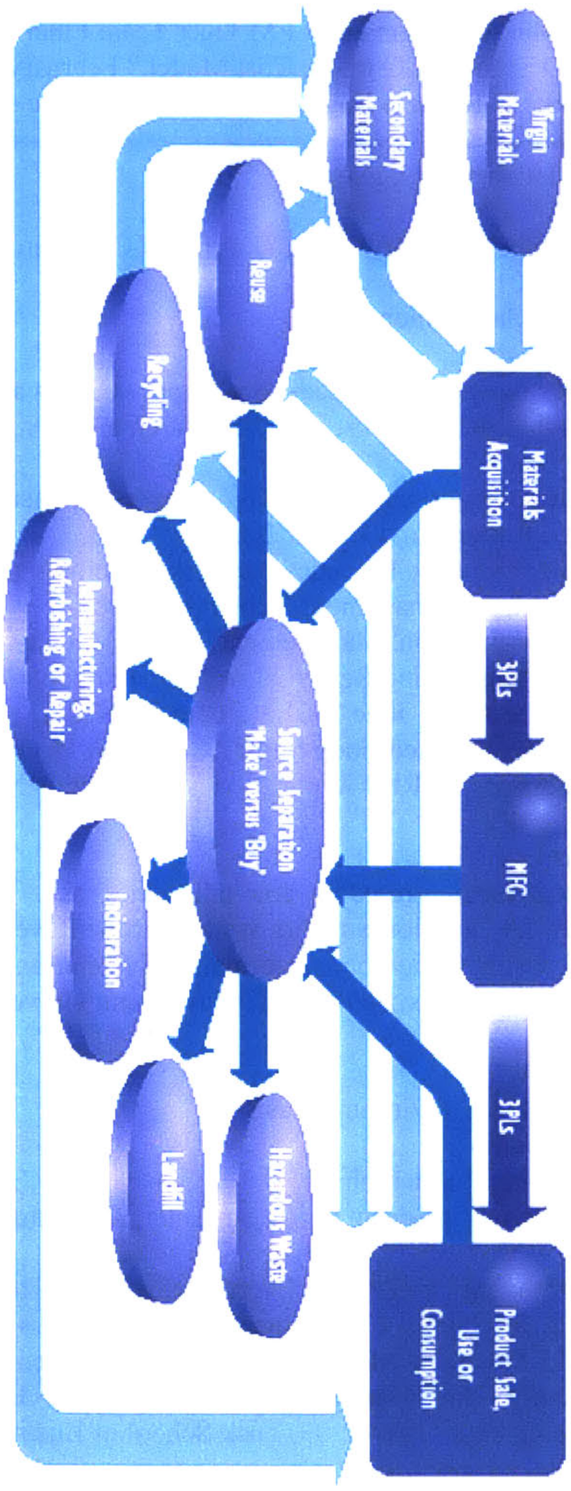


Figure 1: Reverse Logistics Within One Portion of a Typical Supply Chain

Source: James R Stock

[38] Taken from article by James Stock, professor of Marketing and Logistics at University of South Florida, Tampa, entitled "Reverse Logistics in the Supply Chain," published in the Transport and Logistics section of "Business Briefing: Global Purchasing and Supply Chain Strategies," publication date unknown.

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